184

FISCAL YEAR 1997 NASA AUTHORIZATION

Y 4.SCI 2:104/56

Fiscal Year 1997 NASA Authorization...

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

OF THE

COMMITTEE ON SCIENCE

U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTH CONGRESS

SECOND SESSION

APRIL 17, 1996

[No. 56]

Printed for the use of the Committee on Science

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**Vice Chairman

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FISCAL YEAR 1997 NASA AUTHORIZATION

WEDNESDAY, APRIL 17, 1996

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE
SUBCOMMITTEE ON SPACE AND AERONAUTICS
Washington, DC.

The Subcommittee convened at 10:05 a.m. in Room 2325 of the Rayburn House Office Building, the Honorable F. James Sensenbrenner, Jr., Chairman of the Subcommittee, presiding.

Present: Representatives Sensenbrenner, Calvert, Weldon, Stockman, Seastrand, Tiahrt, Rohrabacher, Davis, Foley, Hall, Roemer, Cramer, Barcia, Harman, Luther and Brown.

Chairman SENSENBRENNER. The Subcommittee will be in order.

Good morning, ladies and gentlemen. We are meeting this morning to look into the programs that NASA and President Clinton have requested Congress to fund during fiscal year 1997.

Recently we had NASA's posture hearing with Administrator Dan Goldin to review the President's budget submission for the agency through fiscal year 2000. At that hearing we identified some real problems with the agency's five-year spending plan.

First, there is a large spending shortfall between the programs NASA is carrying forward and the outyear budget that the Office of Management and Budget has programmed for the agency.

Second, there is a significant risk that the budget cuts in the outyears will fall disproportionately upon space science which this Committee has always made a high priority for the agency.

Third, the hard decisions that must be made in order to bring NASA's programs into line with its budget have been left completely to Congress.

Today we will take testimony from almost two dozen experts on how we might make those tough decisions. Several witnesses will talk about efforts to restructure the agency in order to save money. There is a broad agreement that NASA Administrator Dan Goldin has led a remarkable effort to make the agency more efficient. Considerable credit is due to the Administrator and all the NASA employees for the progress that they have made in this area.

Other witnesses will discuss new technology and missions designed to carry the nation's space and aeronautic capabilities forward to the end of the next century. Representatives from NASA and industry will update us on the status of the Space Station and Space Shuttle programs. In many ways these last two programs are the long poles in the tent that sustains the political coalition for NASA's other mission areas. So we have a keen interest in the success of these programs.

Finally, two witnesses will discuss ideas for leveraging state university resources to help improve NASA's outreach in education programs.

Since we have an intensive hearing schedule today, I will dispense with any lengthy discussion of NASA and its future to turn directly to my colleague, the gentleman from Texas.

But before doing so, let me say that because we've got a very full plate today, the Chair is going to enforce the five-minute rule very strictly. That means witnesses will be limited to five minutes, the Chair will be limited to five minutes and Members of the Committee will be limited to five minutes to answer questions and the gavel will go down right at the five-minute mark.

I have given the Majority staff an opportunity to timer training sessions yesterday to make sure that this five-minute rule is strictly enforced.

[Laughter.]

Without objection, the full text of all of the witnesses' testimony will be inserted in the record. Without objection, the Chair will be authorized to declare recesses during roll calls, and it is the Chair's intention at the proper time, somewhere between noon and one, to have about a 30-minute luncheon recess as well. So, without objection, it is so ordered.

And I will now to the gentleman from Texas for an opening statement of five minutes or less.

Mr. HALL. Good morning, Mr. Chairman. Because of your admonition and because of the time constraint and the fact that we have about 20 witnesses to speak I will be brief.

I think that NASA has stepped up to the challenge that Congress and the Administration have given it over the past several years to cut its budget, and they've done this while maintaining its performance. So I think it has been a major effort on NASA's part, and some mistakes may have been made or some problems inadvertently created. If so, I hope that the witnesses that we have today, the wide array of witnesses we have will help us understand the problems and suggest some possible solutions. However, I think we've cut about as much funding as makes sense over the near term if we're to preserve NASA's world-class capability to maintain its world-class set of scientists and engineers.

NASA has gone the full way on cuts, and they've gone above and beyond, more than any other entity in Federal Government that I know of when they've cut as much as they've cut in the last four years. I don't know how we can expect them or anticipate that they can go any further.

As you know, I support the Space Station and I basically support the biomedical research activities that are going to be made possible. I know other Members have other interests in the space program that they believe are equally deserving of support, but I think we need a product out of space, and what better product could you have than a cure of some of the bad diseases, cancer, diabetes and others.

NASA is not a single mission agency, and I realize that. My major thrust is biomedical, and I believe the American people support the broad range of benefits that NASA delivers to our nation.

Mr. Chairman, there has been some uncertainty also about whether there will be a Subcommittee markup of the NASA authorization bill. There is going to be one once its drafted. As you know, I strongly believe that this Subcommittee has an obligation as the body most directly acquainted with the issues to be the first to mark up the NASA bill, and I hope you share that view. When we have that Subcommittee markup, I can assure the Members that I will work to ensure that NASA conducts its programs as efficiently as possible, but that it is also given the resources to do its job. I believe this Chairman wants that same thing, and I'm honored to get to help him attain it.

I yield back my time.

[The prepared statement of Congresswoman Jackson Lee follows:]

OPENING STATEMENT BY CONGRESSWOMAN JACKSON LEE

NASA AUTHORIZATION HEARING

APRIL 17, 1996

Our hearing today is the second and last of our authorization hearings on the NASA budget for fiscal year 1997. And while I am very pleased at the opportunity to discuss some of the very important issues regarding NASA and our country's space and aeronautics program at great length, I also find several things quite interesting and somewhat puzzling.

The first thing that concerns me is the criticism from my colleagues across the aisle which has been leveled against the Administration's budget request for NASA. While I whole-heartedly agree that the budget in the outyears is insufficient to sustain a healthy and vigorous space program and too small to allow the agency to adequately pursue its mission, however, if I am not mistaken, the proposed Republican budget numbers were **very similar.** Surely they have not forgotten this fact, and if so then I am happy to remind them of it.

Even before the Administration's fiscal year 1997 budget request was delivered to our offices, it was clearly understood by all of us that the future was going to be fiscally difficult for NASA. Out of that climate came the decision to move the Space Shuttle operations to a single prime contract. The awarding of this single contract offers a wealth of opportunity in the areas of safety, cost savings, and for minority businesses.

Though there is concern in many quarters about the safety of the Shuttle during and after the transition to the United Space Alliance contract, this also represents an opportunity to actually enhance the orbiter. Streamlining operations and clearly defining responsibility for safety will, I believe, be to the benefit of all.

In transitioning from the government run operation to the USA contract, the members of this committee have a responsibility to ensure that NASA and USA have all the resources they need to successfully and safely complete their goals. If that means that more money needs to be appropriated to the agency for this purpose, then I call upon my colleagues to do our part and consider restructuring the funding so that the job can be done right and without incident.

Additionally, the creation of USA and the awarding of the prime contract will create an opportunity for small and disadvantaged businesses to become part of the USA-lead team. I hope that USA is committed to seeing that small and disadvantaged businesses get an opportunity to become members of their team and I would hope that NASA will continue to work with USA on their efforts. Such businesses have a lot to offer and I believe that they will demonstrate their advantages when given the chance.

Chairman SENSENBRENNER. Thank you very much.

The first panel will be on the Zero Base Review, Restructuring and Institutional Changes at NASA.

The first witness will be Dr. Richard Wisniewski, Deputy Associate Administrator of the Office of Space Flight of NASA.

The second witness will be Dr. Anthony England of the Space Studies Board of the National Research Council.

The third witness will be Dr. W. D. Kay, Associate Professor of the Department of Political Science at Northeastern University.

Mr. Wisniewski.

STATEMENT OF RICHARD WISNIEWSKI, DEPUTY ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. WISNIEWSKI. Mr. Chairman and Members of the Subcommittee, the planning of the Zero Base Review, ZBR, began in the fall of 1994. A small team was used to guide the process and integrate the results. The actual work performed and accomplished represents the efforts of the NASA Center Directors and the Associate Administrators. From its inception ZBR was designed to be an integral part of the NASA budget progress.

Initially ZBR focused on the center's workforce and the work it performed. Each Associate Administrator and each NASA Center Director was directed to conduct a self-assessment of their workforce incorporating as many streamlining and efficiency improvements as feasible to reduce infrastructure requirements. In parallel with this effort independent, agency-wide, cross-cutting, functional reviews were also undertaken. The ZBR process was designed to use all of these reviews and other data and information to achieve even greater efficiencies than those identified by the self-assessments. The ZBR analysis and assessment was to be accomplished by mid-May of 1995 to impact the fiscal 1996 budget process.

In January 1995 the President challenged NASA to meet a reduction of an additional $4 billion in '97 through 2000. The ZBR process was revised to accommodate this objective and other objectives. The centers were provided a set of change principles and a revised NASA center architecture to drive the change process and structure our centers for the next century.

The objectives provided us by the Administrator were to fundamentally changed the way NASA does business, strengthen NASA's position as a premier R&D agency, establish center role assignments and consolidations, and achieve agency-wide savings of approximately $4 billion without impacting programs.

The centers updated their self-assessments by considering additional ways of doing business, more reductions in their infrastructures and changes to their current center roles and missions. The centers completed their analysis and presented their recommendations two months later.

The ZBR team completed the center reviews in early April. A progress report was made to senior NASA management in mid-April. The team's final recommendations were made to the Administrator and senior NASA management on May 10th. NASA's initial ZBR findings were briefed to Members of Congress and the press later in May. The ZBR team was disbanded later that month as originally planned.

The ZBR effort covered a period of approximately eight months. It reflects well on NASA's resolution to deal with the need for changes when an agency can identify, study and undertake such massive restructuring in such a short period of time.

At a summary level this agency-wide effort has defined each center's mission and established areas of excellence, reduced and consolidated NASA's infrastructure, focused on NASA civil service jobs on R&D rather than operations, established full-cost budgeting and accounting principles to better manage programs, transferred program management responsibility to the Field centers from the Headquarters and improved NASA science and R&D programs and identified $4 billion worth of savings.

In June of 1995 specific budget guidelines regarding implementation of ZBR were transmitted by each AA to each NASA center as part of the 1997 budget formulation process, and the final decisions were included in '97 budget submission to OMB.

The ZBR savings are classified into seven categories of change strategies. Almost 75 percent of our savings are associated with restructuring and privatization.

In terms of the NASA current budget structure, about 75 percent of the $4 billion target is contained in human space flight and the agency-wide infrastructure reductions.

Our current estimates indicates that the savings by fiscal year will be about $500 million in '97, 800 more in '98, $1.2 billion in '99 and $1.5 billion in 2000.

Recently the ZBR results were refined and updated. All of the center results were reviewed by the Comptroller and final decisions were reached and factored into the '97 Congressional budget submission. These reviews increased our confidence in the ZBR results.

Implementation of ZBR leaves us with a situation in which 4,000 civil service jobs must be eliminated over the next four years. Now our analysis indicates that voluntary retirement eligibility could provide much of the attrition needed to cover the eliminated jobs.

The ZBR team made a special effort to develop some civil service reduction strategies that would encourage large voluntary reductions. Recently some of the NASA centers have applied some of these strategies to provide opportunities to encourage attrition. We have hopes that more these reduction strategies will be considered and will be successful.

In summary, all of the data that we have reviewed indicate that the NASA team has stepped up to the challenge ZBR presented and is making fundamental changes in the way we operate . We believe that the ZBR process and implementation is still on target to achieve the planned savings by the end of this decade.

Thank you, Mr. Chairman, and I welcome any questions you might have.

Chairman SENSENBRENNER. Thank you very much, Mr. Wisniewski.

[The prepared statement of Mr. Wisniewski follows:]

Hold for Release Until
Presented by Witness

Statement of

Richard J. Wisniewski
Deputy Associate Administrator
Office of Space Flight
National Aeronautics and Space Administration

Before the

Subcommittee on Space and Aeronautics
Committee on Science
U.S. House of Representatives

April 17, 1996

Mr. Chairman and Members of the Subcommittee:

The planning of the ZeroBase Review (ZBR) was inaugurated in the Fall of 1994. A small internal NASA team was appointed to oversee and integrate the effort. Even though there was a ZBR Team to guide the process and integrate the results, the actual work performed and accomplished represents the efforts of all the NASA Centers, JPL, and Headquarters. It was an Agencywide commitment and undertaking.

Initially, ZBR was intended to focus on NASA's workforce and the work it performed. It was the intention of the ZBR to establish a more efficient and effective workforce baseline for FY 1996 through FY 2000. ZBR developed a baseline to understand the deployment of the workforce and introduced new operating guidelines and processes to change the way NASA did business. From its inception, ZBR was designed to be an integral part of NASA's budget process. The ZBR team was directed to consider and integrate as part of its review process all ongoing and planned program restructuring and reengineering activities.

ZBR's first step was to develop a self-assessment process at each Center to inventory the NASA on-and-near- site workforce, civil service, and support contractors. In October of 1994, NASA Headquarters and each NASA Center Director were directed to conduct a self-assessment of their workforce incorporating as many streamlining and efficiency improvements as feasible to reduce the size of the required workforce. Reviews were planned with the Centers for the February/March 1995 time period. In parallel with this effort Agencywide crosscutting functional reviews were initiated in Resources Management, Financial Management, Procurement, Human Resources, Information Systems, Science, and Engineering Standards and Practices. The ZBR process was designed to use all of these reviews, other requested data and ongoing studies, to achieve even greater efficiencies than those identified by the Center Directors self assessments. The ZBR analysis and assessment was to be accomplished by mid May of 1995. Mid May was selected as latest date that would permit the results of ZBR to impact the FY 1996 budget process.

In January 1995, while ZBR was underway, the President challenged NASA to meet a reduction of 4 billion dollars in FY 1997-2000 as part of the FY 1996 budget process. NASA management directed the ongoing ZeroBase effort to respond to the President's challenge and change the way NASA does business without changing what NASA did. The ZBR process was quickly revised. ZBR now focused on changing the NASA Centers for the next century. We were now being asked to provide a framework or architecture that would shape NASA's workforce, facilities, and all other elements of our infrastructure for the next generation. We did make one assumption. No NASA Centers were to be closed. The Centers were provided a set of principles by which to bring about change and a revised NASA Center architecture and specific Center role changes to stimulate the change process. The new guidance and direction was provided in February 1995. The schedule completion date of mid May could not be relaxed.

At this point in the ZBR process we were focused on achieving four objectives:

1. Fundamentally change the way NASA does business
2. Strengthen NASA's position as the premier R&D Agency
3. Establish Center role assignments -- missions and areas of excellence
4. Achieve Agencywide savings of approximately $4 billion in the FY 1997-2000 budget plan

The NASA Centers were given a significant challenge. The Centers were asked to not only plan new ways to do business and reduce their infrastructure, but also to accept changes to their current Center roles and missions. Many of the proposed changes required consolidation of work from one Center to another. All of these changes had to be understood well enough to develop FY 1997 budget guidelines -- program, institutional, and workforce. Each Center was required to consider a large number of changes and issues as their were more than a hundred being examined Agencywide in addition to each individual Center's Director's proposed changes. The Centers were also required to factor into the consideration, where it was appropriate, the Federal Laboratory review, the Kraft Study and the infamous " Red Team White Paper".

The ZBR Team held the Center reviews in March. There were some follow-up activities early in April to better understand the Center issues. A progress report was made to senior NASA management in April 1995. A number of issues were raised which required several weeks to dispose.

The team's final recommendations were made to the Administrator and senior NASA management on May 10, 1995. A few issues and decisions were not resolved in the meeting but were dealt with subsequently in a series of smaller meetings. A press release followed the completion of these activities at which all of the accepted changes were reported. The ZBR team was disbanded later that month as originally planned. The members of the ZBR team moved back into their respective organizations where they continued to play significant roles in the implementation of ZBR in the FY 1996 and FY 1997 budget requests.

The Result

The ZBR effort covered a period of approximately eight months with a redirection occurring three months into the study. It reflects well on NASA's resolution of being the best of the best to see the Agency undertake such massive changes and begin implementing them starting in FY 1996. We believe that the ZBR process was successful in integrating all of the ongoing efforts involving restructuring and reengineering across NASA to accomplish its objectives. This Agencywide effort has:

- Defined each Center's Mission and established Areas of Excellence at every NASA Center and JPL
- Reduced NASA "Infrastructure"
- Established full-cost budgeting/accounting principles to better manage programs
- Transferred program management responsibility to the Field Centers from Headquarters
- Improved NASA's Science programs
- Identified $4 billion savings in FY 1997-2000 while maintaining programs (savings are included in the FY 1997 multiyear budget)

The savings estimates are reflected in the FY 1997 budget submission of the NASA Centers. All of the NASA Centers are committed to achieving the savings. The ZBR categorized its savings into seven categories. These categories reflected some of the operating guidelines that the Team recommended as NASA changes in the way we do business. (The definitions are enclosed.) They are summarized as:

• Efficiencies	$0.85 Billion
• Restructuring	$1.60 Billion
• Privatization	$1.30 Billion
• Outsourcing	$0.125 Billion
• Performance-based contracting	$0. 09 Billion
• Deregulation	TBD
• Commercialization	TBD
TOTAL (Approx.)	**$4.0 Billion**

In terms of NASA's current budget structure, the $4 billion target reduction is contained within thee folloing budgets:

• **Human Space Flight**	**$1.2 billion**
• **Space Science, LMSA, SA&T, Academic**	**$0.4 billion**
• **MTPE**	**$0.2 billion**
• **Aeronautics**	**$0.3 billion**
• **Mission/Space Communications**	**$0.6 billion**
• **R&PM**	**$0.7 billion**
• **ROS/Facilities**	**$0.6 billion**

A significant number of civil service jobs will be eliminated. Since FY 1993 over 4000 jobs have already been eliminated. The ZBR recommended the elimination of 4000 additional jobs over the next five years. The Agency has in place a strategy to achieve those reductions and accomplish them in as humane a manner as possible.

The results that will be accomplished by the end of FY 1997 represent a measure of the success to-date and the commitment of the NASA Centers and JPL to the planned changes. For example, NASA will:

- Close/convert facility assets with an estimated replacement value of $1.9 billion since 1994
- Consolidated the Agency's supercomputing management at Ames, propulsion testing at Stennis, Space Mission Operations at Johnson
- Achieve a reduction of 500 civil service FTEs through attrition
- Establish a Biomedicine Science Institute
- Establish and have in place plans at all NASA Centers and JPL to accomplish their assigned areas of excellence
- Determined the feasibility of commercializing low-earth orbit communications & tracking currently provided by JPL
- Consolidated and awarded the first phase of the Shuttle Flight Operations Contract
- Reduced the NASA budget by more than one-half billion dollars

Our current estimates indicate that the savings by Fiscal Year can be approximated as follows:

FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	TOTAL
$439 M	$531 M	$847 M	$1189 M	$1532 M	$4099 M

The enclosed detailed chart distributes the reduction by program and Center.

Summary

NASA's initial ZBR findings were briefed to members of Congress and the Press in May 1995. At that time the Agency announced its plans to define specific roles and missions for each Center and significantly reduce costs and the workforce.

In June, 1995, specific guidelines regarding implementation of ZBR were transmitted to each NASA Center as part of the FY 1997 budget formulation process. Internal reviews were held in July and August and decisions were included in the FY 1997 budget submission to OMB. A series of senior management meetings were held in late 1995 which culminated in a set of Center reviews in February 1996 at which the ZBR results were presented. All of the Center initiated results were reviewed by the Comptroller and final decisions were reached and factored into the FY 1997 Congressional budget submission in March 1996.

There have been, as you would expect, adjustments to baselines and recommendations, and even some reallocations of resources. However, this iterative process over the last ten months confirms approximately $4 billion budget savings. Implementation is now proceeding on schedule.

The NASA team has stepped up to the challenge ZBR presented and is making the fundamental changes in the way we operate to sustain our core activities and maintain balance among them.

Thank you Mr. Chairman and I welcome any questions you might have.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ZeroBase Savings

FY 1996 PRESIDENT'S BUDGET VS FY 1997 PRESIDENT'S BUDGET SUBMIT

(Millions)

	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 97 - FY 00
DELTA	-439	-531	-847	-1189	-1532	-4099
HUMAN SPACE FLIGHT	-53	-81	-334	-409	-522	-1346
SPACE SCIENCE	74	45	73	94	63	275
LIFE & MICROGRAVITY SCIENCES	-16	-25	19	23	31	48
MISSION TO PLANET EARTH	-52	23	-7	-43	-33	-60
AERONAUTICAL RESEARCH & TECHNOLOGY	-71	-139	-88	-62	-45	-334
SPACE ACCESS AND TECHNOLOGY	-64	-18	-90	-96	-106	-309
MISSION COMMUNICATION SERVICES	-20	-54	-79	-69	-86	-288
ACADEMIC PROGRAMS	-12	-24	-30	-37	-41	-132
FUTURE PLANNING	0	0	-10	-125	-170	-304
SAFETY, RELIABILITY & QUALITY ASSURANCE	0	-1	-1	-1	-1	-5
SPACE COMMUNICATION SERVICES	-50	-77	-107	-94	-86	-364
RESEARCH AND ROGRAM MANAGEMENT	-150	-179	-198	-314	-426	-1117
CONSTRUCTION OF FACILITIES	-24	0	4	-58	-108	-162
INSPECTOR GENERAL	-1	-1	0	0	-1	-2

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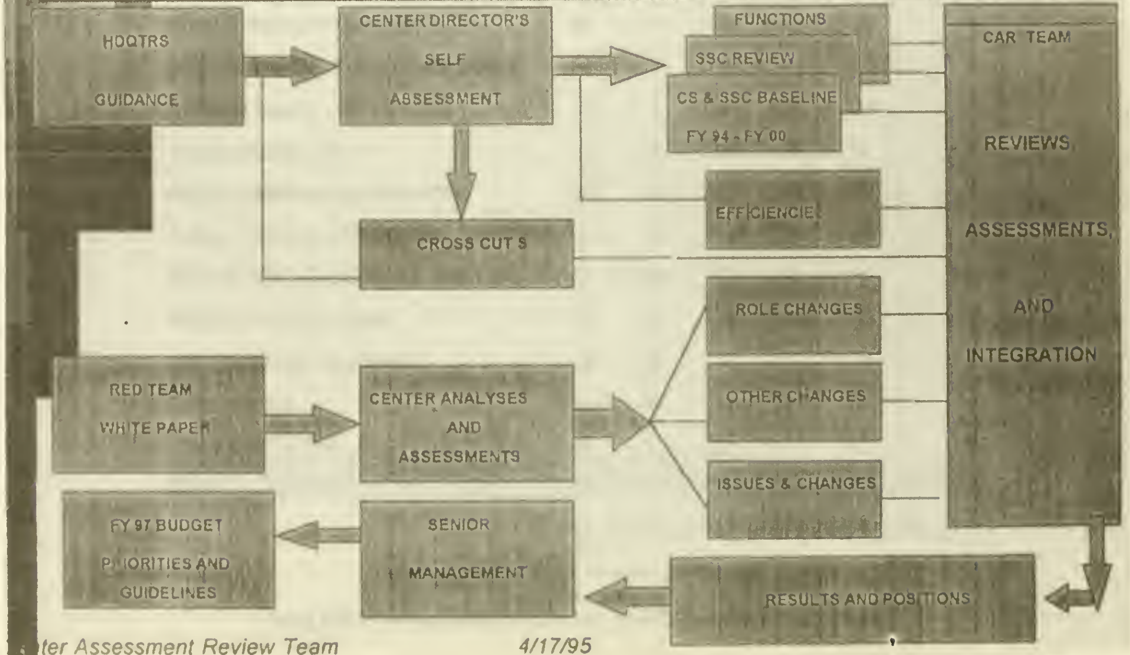

ter Assessment Review Team *4/17/95*

Chairman SENSENBRENNER. Next up is Dr. Anthony England, Space Studies Board of the National Research Council.

Dr. England.

STATEMENT OF ANTHONY ENGLAND, SPACE STUDIES BOARD, NATIONAL RESEARCH COUNCIL

Mr. ENGLAND. Thank you Mr. Chairman and Ranking Minority Member and other Members of the Committee. I want to thank you for inviting the Space Studies Board to testify today. Our Board Chair, Claude Canizares, couldn't make it today. So he asked me to stand in for him.

I'm Tony England. I'm a professor of electrical engineering and of atmospheric, ocean and space science at the University of Michigan, and also Associate Dean of the Graduate School there. My research field is earth science, and I've had about 14 years of NASA experience as a scientist/astronaut both during Apollo and during the Shuttle program. I flew on the Shuttle in 1985. More recently I've been involved with the Space Studies Board for about four years and participated in the recent study on managing space sciences.

The Board interest in NASA's management of science actually began in 1992 with a reorganization of space science from one office to the current three offices. The current migration of program responsibility from Headquarters to the Field Center is a further concern to the Space Studies Board. Our recent Board products concerning NASA's management of science includes two letter reports to the NASA Chief Scientist, both in 1995, and our full-length report on managing the space sciences which came out also in 1985.

My intent today is to briefly review some of our recommendations that relate to the zero base budgeting and to highlight some concerns that the Board has.

In the March 29th, 1995 letter to Dr. Cordova the Board analyzed the science role of the NASA Field Centers and the value of scientists at those Field Centers to NASA space scientists, and our principal findings were these:

The primary mission of NASA center science should be to tightly bind NASA's immense technical capabilities to the diverse and still larger industrial and academic research community around the country.

To carry out this binding function, NASA science and scientists must be excellent in quality and sufficiently broad and deep. NASA science must also be firmly integrated into the agency's infrastructure, and it should foster interdependency among centers. Although a certain amount of competition is healthy for maintenance of quality, NASA Headquarters has an important oversight role in managing this competition between the centers.

On August 11th we sent another study letter to Dr. Cordova, and this one reviewed NASA's proposal to form science institutes. NASA's reason for forming these institutes or stated reason was to improve NASA science. The perceived reason by the outside community was to undergo downsizing with a minimum of pain and maintain science quality in those groups that can compete effectively outside the NASA environment.

Our recommendations in that letter to NASA were these:

Institute planning should be a part of a larger science plan that considers how national space goals will be attained by the sum of all NASA science activities.

Planning should be openly developed and consistently implemented to prevent uncertainty and turmoil from degrading scientific excellence.

According to the earlier letter, center scientists were to play the major role in binding outside science and scientists to NASA's technical capabilities and facilities, but the ability of external scientists who might be viewed as contractors, meaning these institute scientists, to accomplish this role might be impaired.

An important role of center scientists is to diminish center insularity, and it was not clear to the Board how external institutes would do this effectively.

In the fiscal '94 Senate Appropriations report language the Senate encouraged the Space Studies Board to review NASA's management of space science. We interpreted this broadly to mean a review of the Office of Space Science, the Office of Mission to Planet Earth, the Office of Life and Microgravity Sciences and those parts of technology development in the Office of Space Applications and Technology that had to do with the quality of science.

The study took a little over a year and involved three panels, one looking at the organization of NASA science, a second looking at the priorities, and a third looking at the infusion of technology in NASA science. There were 31 recommendations, and I'll not read them all today.

Chairman SENSENBRENNER. Dr. England, your five minutes is up.

Mr. ENGLAND. It's up! My gosh, I'm sorry.

Chairman SENSENBRENNER. Without objection, the remainder of your testimony will be printed in the hearing record.

[The prepared statement of Mr. England follows:]

THE ROLE OF NASA HEADQUARTERS IN SCIENCE MANAGEMENT

Statement of

Anthony W. England, Ph.D.
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National Research Council

and

Professor of Electrical Engineering and Computer Science
Professor of Atmospheric, Oceanic, and Space Sciences
Associate Dean of the Rackham School of Graduate Studies
The University of Michigan

before the

Subcommittee on Space and Aeronautics
Committee on Science
U.S. House of Representatives

April 17, 1996

Mr. Chairman, Ranking Minority Member, and members of the committee: thank you for again inviting the Space Studies Board here to testify this morning. Board Chair Claude Canizares was not able to be here today, and has asked me to come and speak to you on behalf of the Board. My name is Anthony England, and I am a professor of electrical engineering and Earth and space science at the University of Michigan. My research field is Earth science, specifically in remote sensing of land and land cover, and I flew as a Mission Specialist on STS-51F in August 1985. More recently, I was Co-Chair of the technology panel of the National Research Council committee that authored the report *Managing the Space Sciences*.

As you know, the Space Studies Board has been the principal independent advisor to the civil space research program since NASA was created by statute in 1958. The Board's primary advisory focus has been strategic guidance for NASA's many and diverse science programs. During the past year, the Board has also considered and commented in several management areas intimately related to space science. The Board recognizes the downsizing pressures that NASA faces as a result of the National Performance Review and the agency's budget projections for future years. Administrator Daniel Goldin has previously pledged to carry out this downsizing without terminating deserving programs, to the maximum extent possible. The Board endorses this principle, which seeks to preserve the investment, in some cases very substantial, already made in high priority flight programs. One consequence of the adopted approach, however, is a dramatic reduction in the Headquarters complement that has had oversight responsibility for NASA programs. The motivation for forming a number of new science institutes at selected NASA centers is represented as a concern for quality, not cost savings; but it is clear that any actions to preserve or improve program quality must be taken in an environment of increasing budgetary pressure so that the two considerations will be closely coupled.

The Board's recent suggestions and recommendations regarding science management are contained in letter reports from the Board to Chief Scientist France Cordova on March 29 and August 11, and in the Board's full-length report, *Managing the Space Sciences*. The latter report was developed by a special task group chaired by Dr. John Armstrong, formerly of IBM, in response to requests by the Senate Subcommittee on VA, HUD, and Independent Agencies and by Administrator Goldin. In my testimony, I would like to review some of the key recommendations of the Board that relate to the Zero Base Review, and highlight some concerns identified by the Board and its committees as NASA's restructuring proceeds.

The March 29, 1995, letter to Dr. Cordova analyzes the role of NASA's field centers and of the scientists at these field centers in the broader context of U.S. space research today. The principal findings of the Board were that:

- The primary mission of NASA center science should be to tightly bind NASA's immense technical capabilities to the diverse and still larger industrial and academic research community around the country.

- To carry out this binding function, NASA science and scientists must be excellent in quality and sufficiently broad and deep. NASA science must also be firmly integrated into the agency's infrastructure, and it should foster interdependency among centers. Although a certain amount of competition is healthy for maintenance of quality, NASA Headquarters has an important oversight role in managing this competition between centers.

When the Board met last June, Dr. Cordova presented some early thinking about the proposed new science institutes and requested that the Board comment on it. In a letter dated August 11, 1995, the Board cautiously supported the preliminary planning, phrasing its guidance in terms of the previous letter on center science and scientists. Promising to speak more comprehensively in its imminent report, *Managing the Space Sciences*, the Board suggested in the August letter that:

- Institute planning should be part of a larger science plan that considers how national space goals will be attained by the sum of all NASA science activities.

- Planning should be openly developed and consistently implemented to prevent uncertainty and turmoil from degrading scientific excellence.

- According to the earlier letter, center scientists were to play the major role in binding outside science and scientists to NASA's technical capabilities and facilities; but the ability of external scientists who might be viewed as "contractors" to accomplish this role might be impaired.

- An important role of center scientists is to diminish center insularity; it was not clear to the Board how external institutes would do this effectively.

Managing the Space Sciences, which originated in FY1994 Senate appropriations report language, was completed by the Board and delivered and briefed to Administrator Goldin on September 26, 1995. In all, the report offers 31 recommendations in the areas of science management organization, science selection and prioritization, and technology planning and integration. At its February 1996 meeting, the Board was provided a set of formal responses from NASA's executive management team. Some of the report's recommendations that bear most directly on the Zero Base Review and the management changes now underway at NASA can be summarized (with agency responses) as follows:

- "Program management" responsibilities should be split between those that must be retained at Headquarters and the remainder. The former should be assigned to the Strategic Enterprises at Headquarters, and the balance delegated to the field centers. NASA found this recommendation consistent with the results of its own Headquarters Workforce Review and has initiated implementation. Related to this were Board recommendations for strengthening the role of the project scientist and maximizing project responsibility of executing agents. NASA concurred with this finding as well.

- An "industrial funding model" should be adopted for field centers whereby all costs for a given project or program would be identified and managed, including civil service salaries. The Board thought that this would facilitate rational budget and program planning. NASA noted that it had already made a decision to proceed with full-cost accounting for the centers.

- The Board gave a limited endorsement to the science institutes concept, noting that creation of individual institutes should be tailored to specific scientific and facility needs. The Board's report also cautioned that NASA should give advance consideration to the funding evolution of institutes, including transition to a competitive status and mechanisms for shrinking or termination of those that did not compete successfully. NASA agreed to address these concerns as its planning for the institutes evolved.

- The report listed a number of cases where research should be conducted in-house at NASA centers, for example to attract staff of the necessary quality, maintain competence needed for program management, or to maintain and operate unique national facilities. Otherwise, the report recommends that research be conducted out-of-house. NASA concurred.

- A major concern of the Board's report was science selection, how it should be accomplished, and how to ensure equity and the highest quality. The report strongly states that peer review should be continued,[1] and that Headquarters should retain control of the process. The report's recommendations on NASA technology management, developed with participation by the NRC's Aeronautics and Space Engineering Board, likewise urged the use of peer review managed from Headquarters. A key concern expressed in the report is that "The process should be structured such that proposals from either outside or inside the agency are not placed at a real or apparent disadvantage." NASA agreed with the endorsement of peer review, and noted that the institution of full-cost accounting should ensure a level playing field.

The above illustrates a broad consistency between the Board's findings and current thinking at NASA as expressed in agency responses to *Managing the Space Sciences*.

Nonetheless, the distribution of program management responsibilities from Headquarters to the field centers does open the door to some new problems. On the one hand, the separation and integrity of objectives of different elements of NASA's overall program that are maintained in the present Headquarters organization could be weakened. On the other hand, conflicts of interest could arise, especially at the institutes if they in turn inherit some of these program management responsibilities. Let me elaborate on these two possibilities.

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[1] Peer review was recently strongly endorsed also in the NRC report *Allocating Federal Funds for Science and Technology* (National Academy Press, 1995), prepared by a panel chaired by former National Academy of Sciences President Frank Press: "RECOMMENDATION 10. Because competition for funding is vital to maintain the high quality of federal science and technology programs, competitive merit review, especially that involving external reviewers, should be the preferred way to make awards."

On March 6, Administrator Goldin distributed a directive to Officials-in-Charge of Headquarters Offices and Directors of Field Installations entitled "Space Station Budget." This directive, which concerns the powers and responsibilities of the Program Manager of the Space Station Program Office, provides that:

> ... The Program Manager is now responsible for the cost, schedule, and technical performance of the total program, including the science, aeronautics, and technology (SA&T) implementation. The research and user community will respond to the direction of the Program Manager to ensure utilization priorities and requirements are consistent with the overall Space Station objectives.

One implication of this directive could be the substitution of the Johnson Space Station Program Manager for the cognizant Headquarters science office management in planning and oversight of scientific research to be carried out on that platform. The Board has very clearly stated recommendations on this subject. In a letter to Administrator Goldin on February 25, 1994, the Board joined its Committees on Space Biology and Medicine and on Microgravity Research to lay out the hazards of structuring science management along flight hardware development lines. The Board and committees then made the following specific recommendations:

> 2. The Office of Life and Microgravity Sciences and Applications (OLMSA) should be responsible for defining life and microgravity sciences research to be performed aboard the space station. To ensure a broad and balanced research program, including theoretical and ground-based components, OLMSA should actively involve the microgravity and life sciences research communities.
>
> 3. Once it has defined the science program, OLMSA should manage and conduct open solicitation and peer-reviewed selection of all experiments to be flown, including those for both operational and fundamental science studies, in concert with its international collaborators.

This subject is currently of heightened concern to the life sciences research community.

The potential for conflicts of interests at the field center level is most easily seen in the context of the science institutes. Recently, NASA released the "Final Publication" of its *NASA Science Institutes Plan.* While generally consistent with *Managing the Space Sciences*, this exposition of agency planning for the science institutes has left some concerns about implementation. The *Institutes Plan* states that:

> Each institute should have stable funding from NASA to support core service and research functions...Institutes will be encouraged to compete for additional NASA funding (e.g., through grants and funding proposals submitted in response to research announcements. (page 9)
>
> All work assigned to institutes should be the result of a competitive selection process. This competitive process may be part of the initial selection process or subsequent selections for scientific research grants or individual projects. In the case of scientific research, all selections should result from a process that conforms to standard policies including peer review as appropriate. (page 5)
>
> In many cases, the science community will receive funding from NASA via the Institute based on a competitive peer review process...Institutes will facilitate peer reviewed extramural research, and may also engage in peer reviewed intramural research. Enterprises may also delegate authority to Institutes to manage scientific research programs. (page 6)

Thus, only part of an institute's funding will be provided as core funding and the balance must be sought competitively. This, in itself, is not a bad thing, because experience has shown that a brisk competition for resources maximizes research program quality. However, in a situation where an institute would depend to a significant extent on competitive funding in an area for which it exercised program management responsibilities, the possibility of a structural conflict of interest plainly exists. Note that a similar conflict of interest situation could arise in a NASA field center which, finding itself operating under full cost accounting, would be competing for research funding in areas for which it played a program management role delegated from Headquarters.

In its Executive Summary, *Managing the Space Sciences* states that:

> NASA should exercise caution in downsizing its Headquarters staff and transferring functions to the centers; this process could be carried too far and have unintended consequences.

Having identified two areas where such unintended consequences may result, I would like to quote specifically two recommendations from this Board report that we believe would protect the agency from these unintended outcomes:

> Peer review for scientific investigations should be continued. Control of the peer review process should remain with Headquarters, and adequate Headquarters staff should be retained for this purpose. The process should be structured such that proposals from either outside or inside the agency are not placed at a real or apparent disadvantage. (Recommendation 5-8)
>
> Within NASA Headquarters, there must be a capable scientific staff to support management priority setting in order to help ensure compatibility of program and science priorities. These scientists must also interface with field center managers and external investigators to ensure science program integrity. (Recommendation 5-12)

The common element of these two important recommendations is the need to maintain and exercise sufficient scientific expertise at Headquarters. One key role for these science managers should be to impartially oversee selection of research investigators and investigations. In addition, NASA's organizational structure should enable them to cooperate and negotiate with other senior agency officials from a position of parity. The scientific yield of NASA's programs since the inception of the agency nearly 40 years ago is one of the jewels of 20th century civilization. In meeting the policy and budgetary imperatives of today, we should be careful to preserve for tomorrow our ability to extend this record of achievement into the future.

Thank you for your attention; I would be happy to try to answer any questions you might have.

Chairman SENSENBRENNER. Dr. Kay.

STATEMENT OF W. D. KAY, ASSOCIATE PROFESSOR, DEPARTMENT OF POLITICAL SCIENCE, NORTHEASTERN UNIVERSITY

Mr. KAY. Thank you, Mr. Chairman, and good morning. I would like to thank you for giving me this opportunity to share with you my views on NASA reorganization and the 1997 NASA budget.

I bring to this discussion a long-standing scholarly interest in the interaction between government institutions and the process of research and development, and I'm especially interested in this relationship as it plays out in the creation and operation of large-scale, long-term, complex and expensive technologies like those employed in the U.S. Space program. In addition, I specialize in the study of public organizations.

In preparation for this hearing you've asked me to comment on three areas related to the NASA zero base review. First, what enables an organization to remain successful while downsizing, two, the difficulties of decentralizing NASA and, three, how organizational changes may affect operational safety at the agency.

While I address all three of these in my written statement, with your permission in the interest of time I would like to confine the oral part of my statement to the first issue.

Mr. Chairman, as you know, downsizing has become an increasingly important issue for organizations of all types, public agencies as well as private firms both here and abroad. It will come as no surprise that facing a significant reduction in its size, scope or budget is an extremely wrenching experience for any organization.

Research in the social sciences and the field of business administration over the past 10 years has identified a number of problems likely to be encountered by any public agency or private firm experiencing such a reduction. These can include difficulties in internal communication, low employee morale, internal conflict, risk aversion and resistance to innovation and loss of confidence in leadership. The result more often than not is that an organization facing say a 10 percent cut in its budget is likely to find its productivity falling off by a still greater amount.

Let me stress, Mr. Chairman, that there seems to be no way of completely avoiding these types of problems. In a sense downsizing is bit of divorce. Even when it's necessary, it's never very pleasant, and there is really no way to do it right, at least no way that works in every case. Instead, successful downsizing seems to involve keeping the stresses at manageable levels, that is to say, to make the best of a bad situation.

In particular research has shown that the most important factor in cut-back management is the approach taken to it by the organization's leadership. Now having said that, and bearing in mind that we are still very early in the process, I think it's fair to say that NASA's performance in this regard has been very, very impressive.

I have no idea whether Dan Goldin is conversant in the literature in downsizing, but so far he had followed the script almost perfectly and has managed to hit all the right buttons. He has been especially successful I think in framing NASA's restructuring as a net gain rather than simple damage control and to say in effect well budget cuts don't matter so much because we're just doing what we should be doing anyway. The result has been, at least to an outsider, that NASA looks more robust, more active and more innovative than it has in years.

Now this view that I've laid out provides another reason for concern over the recent announcement of additional cuts to the NASA budget beyond fiscal year 1997, that is to say, from the projected $13.1 billion to 11.6 by the year 2000. Much of the agency's success up to this point in keeping some control over the more disruptive effects of downsizing I think lies in the fact that it has managed through a strategic plan, through adoption of new technologies and through its overall new operation philosophy to stay out in front of the potentially corrosive organizational effects of overall government restructuring.

This latest development, therefore, threatens to undermine this carefully developed framework. In other words, Mr. Chairman, the danger of the proposed additional budget reductions go beyond simply the loss in review, and I would strongly urge Congress to continue its support of NASA's excellent work to date by sticking to the existing budget plan.

In effect, Mr. Chairman, some news reports have said that Dan Goldin has become a victim of his own success since, according to some, he has cut so much so successfully he must be capable of cutting still more. The view that I have laid out here, however, suggests that such a conclusion is incorrect.

I think that everyone connected with or interested in the U.S. Space program agrees that Goldin had done the best job possible in playing the cards he has been dealt. That does not mean that we can go on intentionally dealing him progressively worse hands.

Actually, Mr. Chairman, I have much more to say, but in the interest of time I'll just stop here and be happy to take any questions that you might have.

[The prepared statement of Mr. Kay follows:]

Northeastern University

Graduate School of Arts and Sciences
Department of Political Science
Public Administration Program

Before the U.S. House of Representatives
Subcommittee on Space and Aeronautics
Committee on Science

TESTIMONY OF DR. W. D. KAY

Associate Professor of Political Science, Northeastern University

Mr. Chairman, Members of the Subcommittee:

Thank you for giving me the opportunity to share with you my views on NASA reorganization and the 1997 NASA budget. I bring to this discussion a longstanding scholarly interest in the interactions between government institutions and the process of research and development, particularly with regard to large-scale, complex, and expensive technologies (like those used in the U.S. space program). In addition, I am a specialist in the study of public organizations. For this Hearing, you have asked me to comment on three areas related to NASA's Zero Base Review: (1) what enables an organization to remain successful while downsizing, (2) the difficulties of decentralizing NASA, and (3) how organizational changes affect operational safety at NASA.

I. Organizational Success and Downsizing

The Problems

Whether called "downsizing," "cutback management," or the rather odd euphemism "rightsizing,"[1] reductions in the size, scope, and budgets of all types of organizations (including public agencies and private firms) have become an increasingly common occurrence, both in the U.S. and abroad. Although this process has been underway for nearly fifteen years, students of organizational behavior have been exceedingly slow in studying it in any systematic way,[2] and slower still in producing information that might be

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[1] Some of works from the organizational studies literature to be cited here (particularly those published prior to 1991) also use the term "organizational decline." Fortunately, this usage is dying out since, in addition to its unfortunate connotations, it is easily confused with the research on general organizational failure.

[2] See William McKinley, "Organizational Decline and Adaptation: Theoretical Controversies." *Organization Science* 4 (February 1993), pp. 1-9.

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of some use to elected officials.[3] Thus, while we are just beginning to learn a great deal about how organizations react to downsizing, we have not, for example, come up with a reliable method for keeping the productivity of an agency facing a budget or personnel reduction from decreasing by a still greater amount.

Part of the reason for this, I think, lies in the extreme difficulty of the problem. In many ways, organizational downsizing is like a divorce: even when it is necessary, it is almost always exceedingly unpleasant, and there is virtually no way to "do it right" (at least no way that can be prescribed for every situation). It is therefore all but inevitable that an organization forced to make significant cutbacks will encounter some combination of communication problems, low morale, internal conflict, risk-aversion and resistance to innovation, loss of leadership credibility, and other experiences of a similar nature.[4] In theory, the consequences of such upheaval should be especially severe for a high technology-based organization like NASA, where even small mistakes can lead to serious, even deadly, outcomes.

Why Hasn't Anything Bad Happened at NASA Yet?

Given all of this, recent events at NASA come as something of a surprise. Although far from smooth or easy, the agency's current restructuring appears so far to have produced few—if any—of the dire consequences depicted in the downsizing literature. Indeed, NASA appears, at least to those of us on the outside, more robust, active, and innovative than it has in years. I believe that upon closer examination, however, the source of the agency's resilience becomes quite clear, and I would strongly urge the members of the Subcommittee to keep it mind during the upcoming debates over NASA's future.

When considering how organizations respond to declining resources, some scholars make a distinction between those that behave in a "reactive" manner and those that take a more "reorienting" approach to their situation.[5] The former do not regard themselves as being in control their fate in any way; their leaders tend to see their responses to a budget cut (or revenue loss) as "damage control," and seek to retain as many of their regular practices and operations—and as much of their personnel—as possible. These types of organizations do not develop any sort of long-range strategy (other than perhaps to hope that some day their budgets will be restored), but rather react to each new cutback in an ad-hoc fashion. It is easy to see how this style of management can lead to many of the dysfunctional consequences of downsizing (employee uncertainty, low morale, lack of confidence in leaders, etc.) described above.

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[3] There are some exceptions: see S. H. Applebaum, R. Simpson, and B. T. Shapiro, "The Tough Test of Downsizing." *Organizational Dynamics* 10 (1987), pp. 68-79; Kim S. Cameron, Myung U. Kim, and A. K. Mishra, "Best Practices in White-Collar Downsizing: Managing Contradictions." *Academy of Management Executive* 5 (1991), pp. 57-73.

[4] Kim S. Cameron, David A. Whetten, Myung U. Kim, "Organizational Dysfunctions of Decline." *Academy of Management Journal* 30 (1987), pp. 126-138; Robert A. D'Aveni, "The Aftermath of Organizational Decline: A Longitudinal Study of the Strategic and Managerial Characteristics of Declining Firms." *Academy of Management Journal* 32 (1989), pp. 577-605.

[5] See Sarah J. Freeman and Kim S. Cameron, "Organizational Downsizing: A Convergence and Reorientation Framework." *Organization Science* 4 (February 1993), pp. 10-29. For the sake of clarity, I have taken the liberty of substituting the term "reactive" for "convergence."

Leaders of "reorienting" organizations, on the other hand, generally try to take more of an initiative. They usually regard a decline in resources as signalling the need for significant organizational redesign—carried out in accordance with a specific plan—which they represent to their employees (and the external environment) not as an accommodation to scarcity, but rather as the seizing of an opportunity. They almost always promise a *better* organization in the end ("reactive" organizations simply try to hold on). In the ideal case, reorienting leaders will portray cost reductions as a *consequence* of organizational change, rather than a cause.[6] This, in turn, *can* (there are never any guarantees) help alleviate of the problems with morale and (assuming the restructuring is successful) confidence in leadership. Moreover, working according to a strategic plan helps to address difficulties with uncertainty and internal confusion.[7] It is important to note that an integral part of this process is the ability of organization leaders to "frame" the restructuring in a positive way.[8]

Obviously, this second model comes closer to describing the present strategy of the NASA leadership. From the moment of his arrival at the agency (and well in advance of the first deep cutbacks) Daniel Goldin has spoken repeatedly of "reinventing NASA," "changing the way the agency does business," and, of course, creating programs that are

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[6] ibid; see also David A. Whetten, "Sources, Responses, and Effects of Organizational Decline" in John R. Kimberly and Robert H. Miles (eds) *The Organizational Life Cycle*. San Francisco: Josey-Bass, 1980, pp. 342-373, especially the discussion on "attitudes toward change."

[7] Downsizing in accordance with a long-range plan has the added benefit of reducing the uncertainty and confusion among the organization's members. Most observers agree that, as bad as an announcement of impending layoffs can be, no information is even worse. See Robert I. Sutton, Kathleen M. Eisenhardt, and James V. Jucker, "Managing Organizational Decline: Lessons From Atari." *Organizational Dynamics* 14 (Spring 1986), pp. 17-29; Daniel C. Feldman and Carrie R. Leana, "Managing Layoffs: Experiences at the Challenger Disaster Site and the Pittsburgh Steel Mills." *Organizational Dynamics* 18 (Summer 1989), pp. 52-64.

[8] A similar approach is described in Zebava Rosenblatt, Kathryn S. Rogers, and Walter R. Nord, "Toward a Political Framework for Flexible Management of Decline." *Organization Science* 4 (February 1993), pp. 76-91.

"faster, better, cheaper." The proposed restructuring of NASA (including the reorganization of the NASA centers, about which I will say more below) is an integral part of its current *Strategic Plan*, which effectively connects the "revolutionizing" of the agency to its mission and long-run goals.[9] Most important, these representations have been reinforced by specific initiatives an innovative projects like Discovery and the X-33 (present difficulties notwithstanding).

In short, what the Goldin regime has managed to do (at least up until now) is to keep NASA out in front of the more corrosive effects of budget cutbacks. Like any effective reorienting leader, he has "framed" the agency's situation in a way that, in effect, suggests: "the budget cuts don't really matter to us because we are just doing what we should be doing anyway." This successful redefinition of NASA downsizing as a series of steps toward greater efficiency and increased productivity (as Goldin puts it, a "NASA that is better than ever") is, I think, a remarkable achievement.

Prospects for the Future

In reviewing the status of NASA's restructuring, I can see two potential dangers to the agency's ability to maintain its current level of effectiveness and productivity.[10] One is the possibility that some of the negative effects of downsizing will yet emerge. I will discuss this in greater detail below. The other, simply stated, is *surprise*. Any unexpected external event that calls into doubt the impression that NASA is "on top of" events could seriously undermine the framework that Goldin and his colleagues have crafted.

One such event would be a major mission failure. Another, and one which is of more immediate concern, *could* be the recently announced budget projections for NASA beyond 1997. These budget totals fall far below even the most pessimistic agency estimates, and could—by invalidating large parts of the *Strategic Plan*, making irrelevant many months of difficult and delicate work, and by forcing NASA (once again) to play "catch up" to outside events—have a devastating impact on the agency's restructuring. This is important: the negative impacts of the proposed budget reductions go far beyond the simple loss in revenue.

Some news reports have characterized Goldin as a victim of his own success. Since, according to some, he has cut so much so successfully, he must be capable of cutting still more. The analysis presented above, however, strongly suggests that such a conclusion is incorrect. Everyone connected with or interested in the U.S. space program agrees that

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[9] U.S. National Aeronautics and Space Administration, *NASA Strategic Plan*. Washington: NASA, 1996.

[10] Bearing in mind, of course, that we are still very early in the process.

Goldin has done the best job possible in playing the cards he's been dealt. That does not mean that we can go on intentionally dealing him progressively worse hands.

II. NASA Decentralization

Advantages

One of the major organizational reforms currently underway is the move toward greater "decentralization" with regard to the NASA field centers. The primary purpose of this is to "reduce overlap and streamline administrative functions across the Agency."[11] It is not clear whether NASA is aware of this (i.e., I have not seen any officials comment on it publicly), but there are a number of other benefits to be gained from such a move.

First, decentralization—a reduction in organizational hierarchy and a granting of greater autonomy to the lower levels of an organization—is a common response of an organization to an increasing level of uncertainty or "turbulence" in its external political, social, or economic environment.[12] In other words, an agency in which decision-making authority is more widely dispersed is said to be more "flexible," and better able to deal with unexpected events than a more centralized, "rigidly bureaucratic" organization.

Moreover, a decentralized organizational structure is generally held to be more compatible with activities like scientific research and technological development.[13] Hierarchies, formal rules and procedures, and other features of traditional bureaucracies presuppose a certain level of routine and a high degree of *a priori* knowledge, conditions which by definition do not exist in organizations dedicated primarily to R&D. In short, the proposed move may very well lead to even higher-quality research on the part of the NASA field centers.

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[11] *NASA Strategic Plan*, p. 6.

[12] See, among others, James D. Thompson, *Organizations in Action*. New York: McGraw-Hill, 1967; and Henry Mintzberg, *The Structuring of Organizations*. Englewood Cliffs, NJ: Prentice Hall, 1979. For a discussion of the organization/environment interaction as it applies to space policy, see W. D. Kay, *Can Democracies Fly in Space? The Challenge of Revitalizing the U.S. Space Program*. Westport, CT: Praeger, 1995, especially chapter 3.

[13] See Charles Perrow, "A Framework for the Comparative Analysis of Organizations." *American Sociological Review* (1967), pp. 194-208: Henry Mintzberg, *Structure in Fives: Designing Effective Organizations*. Englewood Cliffs, NJ: Prentice Hall, 1983. Peter W. House and Roger D. Shull, *Managing Research on Demand*. Lanham: University Press of America, 1985.

Thus, for a number of reasons (including some that may not be apparent to the agency itself) this move regarding field centers seems to be largely positive, and should be encouraged—in all respects—by Congress and the Administration.

Pitfalls

Unfortunately, much of what we know about organizational evolution suggests that some dangers may lie in wait for NASA as this decentralization moves forward. It is important for both the agency and Congress to be aware of how and where the process can get untracked. First, despite the fact that the move makes sense from a number of perspectives, for organizations in NASA's position there are almost always internal forces that are simultaneously pushing it in precisely the opposite direction, that is, toward still *greater* centralization.[14]

The most likely source of this (at least for the foreseeable future) will be the negative side-effects of downsizing discussed earlier. Research has shown that leaders of organizations facing a decline in resources are frequently tempted to exert greater control over decision-making, rationalizing such moves as "making sure that nothing is going to waste," or to insure "proper coordination." Increased centralization can also be a common reaction to the discontent and internal conflict that usually accompanies downsizing.[15]

Another potential source for trouble is the possibility of increased rivalry among the centers themselves. There is some precedent, particularly with regard to larger NASA programs (and, again, when faced with declining resources), for the competition between the centers to have an adverse impact on project outcomes. Similarly, there is always the danger that increased autonomy will lead to greater parochialism, that is, the tendency to place the interest of individual centers ahead of that of the agency as a whole. The challenge for the NASA leadership must be to take care that this does not occur, while at the same time resisting the impulse to remedy it by "re-centralizing."

III. Organizational Change and Operational Safety at NASA

Perhaps the one of the most important changes at NASA, and the one that has become the most controversial, is the decision to turn the operation of the space shuttle over to a single contractor. As the question presented to me indicates, most of the controversy surrounding this move relates to spacecraft safety. Specifically, there are doubts about United Space Alliance's ability to operate the Space Transportation System safely, particularly at the lower levels of funding projected for shuttle operations.

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[14] For a general discussion of problems like this, see Herbert Kaufman, *Time, Chance, and Organizations: Natural Selection in a Perilous Environment* (2nd edition). Chatham, NJ: Chatham House, 1991; Danny Miller, "Environmental Fit Versus Internal Fit." *Organization Science* 3 (May 1992), pp. 159-178.

[15] Cameron, et. al., 1987; D'Aveni, 1989.

I am, of course, as concerned about safety as anyone, but my own reservations about this arrangement come from what I regard as a prior question, namely: will this move really work as advertised, that is, will it actually realize the promised cost savings? If the answer to this question is no, meaning that the new policy does not even produce the benefit for which it was originally proposed, then it should not be done at all, and the question of safety therefore becomes moot. And I must say, based upon what I have seen, it is not at all clear to me where the cost reductions come from.

Contracting, as widely practiced by many levels of government, is not merely an end in itself. It is, rather, a means to an end, whereby a "monopoly" service provider (i.e., a government agency) is opened up to market forces, creating an incentive for it to operate at lower cost, produce goods or services of higher quality, and so on.[16] Since there is one—and only one—contractor, and therefore no real competition, it is difficult to see how "market forces" will be operating in this case. There may well be some justification for adopting this arrangement (such as "getting NASA out of operations," although I have some doubts about this as well), but it is difficult for me to see how reducing the cost of the shuttle can be one of them.

IV. Concluding Observation

As I stated in my book on the U.S. space program, NASA as an organization faces an unusually difficult challenge. It is charged with developing ever more advanced technologies and conducting increasingly sophisticated scientific investigations (an exacting undertaking even in the best conditions). At the same time, the political and economic environment surrounding the agency has grown much more complex and demanding. Not surprisingly, the book (written before most of the reforms sought by Goldin were announced) takes a rather negative view of the future of the program. If I were writing it now, I think that I would be more optimistic, albeit tinged with a bit of caution. The present NASA leadership, it seems to me, is doing the best job possible under the circumstances. Whether these circumstances will let them continue doing their jobs is another matter.

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[16] E. S. Savas, *Privatizing the Public Sector: How to Shrink Government.* Chatham, NJ: Chatham House, 1982 (especially chapter 5); and *Privatization: The Key to Better Government.* Chatham, NJ: Chatham House, 1987. See also President's Commission on Privatization, *Privatization: Toward More Effective Government.* Urbana: University of Illinois Press, 1988.

Chairman SENSENBRENNER. Thank you very much.

The gentleman from Florida, Dr. Weldon.

Mr. WELDON. I thank the Chairman, and I apologize that I missed your testimony, Mr. Wisniewski, but I'll be reviewing your written testimony. I do have a few questions for you that I think are fairly important.

I don't know how much you touched on this in your verbal testimony, but in terms of the restructuring and streamlining do you feel at this point that NASA is on track with those proposals and plans?

Mr. WISNIEWSKI. Yes. You weren't here, but we have had a recent review, an update a year later, and it still looks to us like we're on track.

Mr. WELDON. What is your impression of the new management structure that has emerged especially as it relates to the Space Shuttle program?

Mr. WISNIEWSKI. I assume you're speaking to the lead center concept?

Mr. WELDON. Yes.

Mr. WISNIEWSKI. I see the lead center concept as a workable concept. It is not a repeat or what was in effect at the time of the Challenger accident. Clearly the chain of command, which didn't exist very firmly at the time of the Challenger accident or wasn't well defined, is very well defined today. So I think it's a workable concept.

Mr. WELDON. So you feel that it is significantly different from the pre-Challenger structure and that some of those problems that existed beforehand will not occur?

Mr. WISNIEWSKI. I think it's significantly different in terms of the chain of command and the amount of communication that exists today in NASA.

Mr. WELDON. Do either of you two gentlemen have any comment on that or any knowledge of that regarding the proposal to change the way NASA manages the Shuttle program? I assume, you're smiling, that you don't know what I'm talking about.

Mr. KAY. Yes, I do. Actually I was thinking more as you were talking along the lines of the contractor arrangement. I do have some thoughts about that if you want me to speak to that.

Mr. WELDON. Well, yes, actually I would. I was actually referring to the plan to go to a lead center and take the management of the Shuttle program out of Headquarters and move it to Johnson Space Center. You're welcome to comment on both of those. I think I have two minutes left or three minutes.

Mr. KAY. My concern about the contractor arrangement, and I know that most of the discussion has been about safety. As a political scientist I studied a lot about contracting arrangements, as they're employed by all levels of government, and my biggest question about that arrangement is I don't see how it is going to achieve in and of itself cost reductions that are being promised for it. Contracting supposedly works by opening an organization up to market forces, and I don't see how that operates in this case. I'm as concerned about safety as anybody else, but my primary concern is just from the start if it's going to achieve the promised goal.

Mr. WELDON. Let me follow up on some of what you just said because one of the issues that I'm very concerned about is maintaining the safety of the Shuttle program through this process of reorganizing and possibly some significant downsizing in the level of personnel. Morale is something that I have perceived to be suffering at the center in my district, Kennedy Space Center, and I'm very concerned in that we're not talking about AT&T here where we make telephones, and we're not talking about, you know, some company that makes soup or whatever.

Every Shuttle is on CNN every time it takes off and every time it lands. The whole nation is watching this. It was a devastating experience for our nation in the Challenger disaster. Maybe I'm painting you in a corner, but do you honestly believe that we may be having a significant problem in terms of trying to implement what's going on in the private sector to an organization that's doing something. It's just a different model I guess and it doesn't quite fit.

Mr. KAY. Congressman, as I said in my statement and mentioned in my written testimony, a decline in morale is an inevitable part of any sort of downsizing move and that the challenge for an agency is to try to keep that minimized as much as possible.

And I agree with you, and I mentioned this in my written testimony as well, that the features that occur any time a firm or company or agency downsizes are more severe for a high-tech agency like NASA where simple mistakes, as we've seen, can turn into rather serious outcomes. So I think it is a cause for concern. I would hope, and again I'm speaking as an outsider, I would hope that forewarned is forearmed and that agency is aware of this potential and is taking steps to deal with it.

Chairman SENSENBRENNER. The gentleman's time has expired.

Mr. WELDON. Mr. Chairman, I assume we are able to submit a written opening statement for the record?

Chairman SENSENBRENNER. Yes, without objection.

Mr. WELDON. Thank you.

[The opening statement of Congressman Weldon follows:]

OPENING STATEMENT OF CONGRESSMAN DAVE WELDON (R-FL)

HOUSE SUBCOMMITTEE ON SPACE AND AERONAUTICS

FISCAL YEAR 1997 NASA AUTHORIZATION HEARING

This is our last hearing on NASA's FY 1997 budget, and I look forward to hearing from the many panelists that will be appearing before us today.

I and many of my colleagues on the subcommittee have expressed grave concerns over NASA's outyear budget projections. I remain convinced that the White House, not NASA, is driving the outyear budget numbers, and that OMB has done so without regard to NASA's actual needs.

As a result, it will be exceedingly difficult for us to convince our colleagues in the House and Senate that NASA should receive any more funding than was requested in President Clinton's budget. We will have to fight hard to ensure his precipitous spending plan does not devastate our nation's space program. Additionally, I will fight to ensure our human space flight programs are not jeopardized by pressures elsewhere in NASA's budget. Most notably, I strongly disagree with NASA's assignment of Mission to Planet Earth as a top priority in the outyears, and am even more disappointed to not find the Space Shuttle or X-33 program anywhere in that listing.

Given those concerns for the outyears, our focus today is the FY 1997 budget. I am generally pleased with NASA's budget proposal for the upcoming fiscal year, and am optimistic that we can achieve similar funding levels in the authorization and appropriation bills.

The Space Shuttle and Space Station programs both receive stable funding levels, allowing those programs to continue a track record of excellence. While I remain concerned about Russia's future in the Space Station program, I am very impressed by the cost and schedule performance and the hardware development of the program. It is indeed impressive to see tens of thousands of pounds of flight hardware taking shape around the world.

The Space Shuttle has successfully embarked this year on Phase One of the Space Station, and I am exceptionally proud of the dedicated personnel at the Kennedy Space Center for their work on the Shuttle program. I am still carefully watching the transition to a single prime contractor for Shuttle operations, and will continue working closely with NASA and United Space Alliance as they encounter and resolve issues. Safety is paramount in this transition, and I will continue to ensure that the focus remains on safety throughout the transition.

Additionally, I am closely following NASA's transition to a lead center approach for program management. There have been a number of criticisms of the new structure, especially in its similarity to the pre-Challenger structure. I hope NASA will successfully perform within this new paradigm to prove the critics wrong.

I look forward to hearing these subjects and many others discussed today.

Chairman SENSENBRENNER. The gentleman from Florida, Mr Foley.

Mr. FOLEY. Let me see if the gentleman from Florida would like to occupy some of the five minutes allocated to me for further questions. I just entered the room.

Mr. WELDON. I appreciate the gentleman's offer.

Mr. England, you didn't really get a chance to comment on my line of questioning.

Mr. ENGLAND. I'm very interested in your line of questioning. I can't speak though as a member of the Space Studies Board. We haven't examined that. As a former astronaut I have opinions, but they can't be construed in any way as being associated with the Board.

Mr. WELDON. Well, I just want to elaborate then a little bit on this issue, because I just had my staff do some studies, and NASA, you know, has downsized its number of personnel dramatically, and you alluded to this in your comment, you know, that the better job you do at downsizing the more downsizing you're asked to do.

But the figures compared to some agencies, and I had them compare the EPA and one other agency that has literally grown over the past six years by 8 or 10 percent while simultaneously NASA has declined by 7 or 8 percent in both civil service personnel and contractor personnel, and now we're proceeding along a budgetary line that is asking for deeper and deeper reductions. While many of these other agencies may not be growing any more like they used to, and I believe that there really is a perception amongst the rank and file, both the civil service and the contractor personnel, that they're essentially being screwed for doing a good job. Actually it was Energy. The Department of Energy has grown 10 percent. EPA has grown 8 percent while NASA declined 8 percent.

I personally feel that if we continue on some of the budgetary trends that we're on that the impact that this is going to have, and you really kind of cruised over safety, and when you made your opening comments I was hoping that you were going to zero in on safety.

Maybe Mr. Wisniewski can comment on this a little bit more, but I feel that what NASA is involved in, at least in the phase that occurs in my Congressional district, which is the most crucial aspect to the whole manned space program, is just getting up in the air and getting it up in the air safely.

There are just crucial issues here, and nobody has presented to me a plan that shows where you can remove people and continue to do the operation safely. It seems to be driven by dollars rather than a legitimate realization on people's part that there is an excessive amount of redundancy or that there are better safety ways to do this to make it safer with fewer people, so to speak. I remain very concerned that that's the situation and that it is having a very significant impact on morale, and maybe you can comment on that Mr. Wisniewski.

Mr. WISNIEWSKI. Well as someone who led the zero base, I, too, felt, even though I did it all, that NASA sort of got screwed in this whole thing. I really feel felt that there were other ways to make the government more efficient. Regardless, I also felt though that NASA had to change.

Speaking specifically at Kennedy, it is true that when we did the zero base at Kennedy the model we had for the center and the model we have today has changed. But if you look at the adjustments that have been made, we essentially are now looking at providing to the Shuttle program at Kennedy what they say they need to get the job done safely from a civil service point of view.

I think that originally when they did the zero base they said they needed 545 people, and we allocated some number in the zero base like 350 or something. Since then it has been re- examined again in light of the transition required in this restructuring of the contract, and in actually looking in great analysis and in depth at what the individual people do, and I think we're up to a number like 545 now on the Shuttle, which is a little bit higher than the 533 number that they originally gave out in the zero base.

So I think we have at least satisfied the Center Director and their senior management as to the level of workforce they need there, but there are a lot of other problems with, and I understand that. I agree with you that morale is down. I noted that when I looked at some of the studies done there that it looks like the closer you are to the hardware the better your morale.

Mr. WELDON. I thank the gentleman for yielding.

Chairman SENSENBRENNER. The time of the second gentleman from Florida has expired.

The gentleman from Kansas, Mr. Tiahrt.

Mr. TIAHRT. Thank you, Mr. Chairman.

I'm a little puzzled, Dr. Kay, about your comments on contracting. I think your philosophy, if I understand it right, is that you fail to see how there is an economic justification for contracting outside. Is it primarily economic, or does it go to the roots of program management or systems engineering functions, or are you concerned about safety issues by going out to contractors? How is it confined?

Mr. KAY. I'm addressing specifically the economics of the arrangement, and what I feel is that when we employ contracting across a variety of services it is a means to an end, and the end is that employing a contract will open up the organization to market inducements and that will lead them to operate more efficiently or provide higher quality or whatever it happens to be.

I have yet to see, and I could be completely wrong about this, but I have yet to see how that operates in this case. Since we have only one contractor, there is no competition to speak of. I mean it's not clear to me from an economic point of view how the market forces, which is the normal justification for moving to a contracting arrangement, are working here. As I say, I could be wrong, but I have not been shown that yet. I would love to be shown that in fact.

Mr. TIAHRT. Well I understand that when you have just one person. I think that new ideas injected into the management techniques and the systems engineering techniques often come from outside an environment that gets set in its ways, and if you believe in the philosophy of Edward Demming of total quality concept, hopefully it's somehow brought into the process and you continue to improve the process. But you're right on an economic basis and I think you've got a good point.

Mr. Wisniewski—"Wisnieski" is correct, right?

Mr. WISNIEWSKI. Close enough.

[Laughter.]

Mr. TIAHRT. I have one of those names that people often confuse, too, so I'm a little sensitive to it.

Chairman SENSENBRENNER. If the gentleman from Kansas will yield, I will invite you to Milwaukee which has a significant Polish American population and your pronunciation will get much better then.

[Laughter.]

Mr. TIAHRT. Thank you. I may take you up on that offer some day.

Do you feel that the morale is down I assume in NASA because of downsizing or threats of downsizing, and, if so, has that impacted the performance of employees?

Mr. WISNIEWSKI. Yes, I think the morale is down. It's hard to be up when you've done a good job and you don't understand why you're being downsized after doing a good job. But I think it's a class act we've got in NASA. People put the program first and they put their emotions aside as best they can and deal with it. I mean that's about the only thing you can do.

Remember, most people are working at NASA because they're excited about what's being done. They want to be there, and we had lifetime employment before the Japanese ever thought of it.

Mr. TIAHRT. The zero base concept that you're going with, did you set a goal and then try to achieve the goal, or was it more driven from the bottom up or the top down in your process?

Mr. WISNIEWSKI. When we initiated it in the beginning we were just trying to become more efficient and more effective, and then when the President reduced the budget in January we had to really deal with $4 billion. However, in all honesty, the process went all the way through to the first week of April before the team ever sat down and determined whether or not we had accomplished the savings we were supposed to. That's the first time we really put a budget together and saved what we were supposed to, and we were damned lucky.

Mr. TIAHRT. Do you feel like this was a successful process and the zero base is going to work?

Mr. WISNIEWSKI. I think it's going to work because it's NASA. I think trying to do this job in 10 months was a real challenge, and it would have been better in hind sight if we had more time, but we didn't.

Mr. TIAHRT. I would like to yield to the gentleman from Florida for another question.

Mr. WELDON. Just one more question. When you did your analysis did you account for unplanned work? As I understand it, for a lot of the people engaged in unplanned work problems just keep coming up over and over again that people didn't anticipate, and was there a provision for that? For example, the recent singeing of O rings that requires a lot of analysis on the part of engineers and time and resources.

Mr. WISNIEWSKI. It's of course difficult to plan for unplanned work, but what we did was we looked at the amount of capability that we would have to keep in place, from an engineering point of view, across the OSF centers, and from that perspective we felt that we had the right disciplines and the right level of engineering to be able to handle that kind of a situation, but it's judgment.

Chairman SENSENBRENNER. The gentleman's time has expired.

The gentleman from Indiana, Mr. Roemer.

Mr. ROEMER. Thank you, Mr. Chairman.

My first question I think would be to Dr. England. Dr. England, the Space Station centrifuge continues to be a major area of concern for many of us on this panel and many in the scientific community. There are indications that the development and flight of the centrifuge might slip because of budgetary pressures. Do you think this is a big problem at this point, and could you expound a little bit on why you think that might be a problem?

Mr. ENGLAND. I would be happy to. I'm not a life scientist. So I'm going by other people's opinions.

Mr. ROEMER. Well don't let that stop you when you're on Capitol Hill, Dr. England. We all have lots of opinions on everything up here.

[Laughter.]

Mr. ENGLAND. Well most of us believe that the Space Station, the primary value to the science of a Space Station will be in the life sciences, and that value has to do with being in a microgravity environment, and the centrifuge allows you to do experiments calibrated through the whole range of available G loads. So to do good life science it has been accepted that we need that centrifuge.

It seems like every time the scientists look the other way the centrifuge is disappearing on us, and we have to come back and argue its value. We've done that successfully each time it seems, but certainly with great enthusiasm each time, because we really believe that that's an essential part of the ability to do science in the Space Station.

Mr. ROEMER. Let me ask you, do you know then at what point we are in terms of the impact on the budget and slippage of schedule? Can you comment on that, or is that not within your purview?

Mr. ENGLAND. No, I'm sorry, I don't know. I can provide letter reports that we've produced on the centrifuge, but I'm not intimately involved with it.

Mr. ROEMER. Okay. There are some in Congress or in different Committees that basically say that we should just concentrate on basic research and cut back on such projects as Mission to Planet Earth. How might you react to that kind of theory or explanation about where we go in this budget?

Mr. ENGLAND. Over probably pretty much my career of 35 years or so the earth sciences have grown to recognize the interdependence of the different disciplines. No longer can you just be an ecologist or a marine geologist or an abstract scientist. All of these play together, and they not only play in their region, but most of them play in some sort of a global basis.

NASA is uniquely positioned to address global issues because it has this world perspective from the satellites that it flies. Also, as we develop these new sciences, that we now call earth system science, we need new technologies and new instruments and new ways to look at things, and these simply don't exist because we haven't done this kind of science before, or not for very long at least.

NASA in this new science is extremely important and losing its participation would greatly cripple our studies of global change or our understanding of how the atmospheres and the oceans exchange energy or how the changing atmospheres are going to change the ecological system on the continents. So I think that that participation is essential.

Mr. ROEMER. Dr. England, and then I would open it up to the rest of the panel as well, too, we have heard from people that have currently moved on from NASA that they're very, very concerned about Shuttle safety. They have gone public in their criticism of some of the reorganization and restructuring of NASA, which I think is a very unusual step. I think NASA employees for the most part don't have that proclivity to do that after resigning or retiring from NASA. But there have been some very, very pointed criticisms of this restructuring and Shuttle safety. How might you comment on what you have read from these individuals, what are you hearing internally from NASA employees, and what recommendations might you give to this Committee so that we ensure that our Shuttle program is as safe as it can be?

Mr. ENGLAND. Again this isn't an opinion of the Space Studies Board because we haven't looked at this. This is based on my 14 years of experience with NASA and during Apollo and then during the Shuttle program plus the friendships that I have with other folks who have now left NASA. We are concerned. The Shuttle is an extremely complicated vehicle. It's a fantastic engineering device, and it's something we all have a right to be proud of, but it's extremely complicated and you can't take it for granted. It will turn around and bite you.

I am just very concerned about localizing the management structure in a center without broader agency sort of competition to view the quality of decisions when you balance the need to fly against the need for safety or something else against something else. You need those debates to go on in the open to get the best engineering solution. So that's my concern.

The concern about the number of employees who are working on a vehicle, that's somehow related to the flight rate, and that level of detail I really couldn't comment on. But I am concerned if decisions aren't made in the open with people who don't have vested interests assisting in those decisions.

Chairman SENSENBRENNER. The gentleman's time has expired.

Mr. ROEMER. Mr. Chairman, could I just ask——

Chairman SENSENBRENNER. I've banged the gavel on the people on my side of the aisle right when the five minutes are up, and what's good for the Republicans is good for the Democrats.

The gentleman from California, Mr. Calvert.

Mr. ROEMER. Mr. Chairman, could I just ask you a question?

Chairman SENSENBRENNER. Certainly.

Mr. ROEMER. I was not going to question your fairness or bipartisanship. I was just going to say could I get an answer to that question from the other two individuals on this panel in writing since I know you're in a hurry to get through all six panels.

Chairman SENSENBRENNER. Absolutely.

Mr. ROEMER. Thank you.

Chairman SENSENBRENNER. The gentleman from California, Mr. Calvert.

Mr. CALVERT. Mr. Chairman, I have no questions for this panel.

Chairman SENSENBRENNER. Thank you.

The gentleman from Alabama, Mr. Cramer.

Mr. CRAMER. Thank you, Mr. Chairman.

I'm playing catch up here in order to spare the Committee and the panel as well. Dr. England, some in the life and microgravity sciences community have expressed concern that NASA's decision to put responsibility for scientific payload funding and management under the Space Station Program Manager could result in those payloads being delayed or descoped. Could you talk to me some about that.

Mr. ENGLAND. The Space Studies Board in general is concerned about the whole transition of science program management from Headquarters to the field centers because each field center has a particular mission. For example, the Johnson Space Center mission is primarily systems development and operations. They do that very well, but in that environment the concern for science is likely to be devalued, and when decisions are made between an expensive piece of hardware that has to be finished and some science, it's likely that science will suffer.

So we are very concerned about mixing responsibilities in a group that generally has a single mission, and we would urge NASA to keep a strong science management overview at Headquarters so that the science activity can remain open and be openly reviewed. When it gets buried down in the operations that is often lost.

Mr. CRAMER. Will you still maintain a strong and rigorous peer review process?

Mr. ENGLAND. We would like to. The life science at NASA historically, I'm afraid, has not been terribly strong, and it has been growing out of that over the last few years largely, I think, due to increased openness in participation by the broader research community in the life sciences, the NIH participation and generally scientists who haven't been involved with life science in space. This has been very healthy, and, as we look forward to the Space Station as an opportunity to do some really exciting life sciences, we would like that maintained.

Some of the changes in program management of the science program have the potential for going back more the way it was. The reviews of some of the life science at Johnson Space Center were not strong. In fact, they were particularly weak, and under this management plan the management of the life sciences in the Space Station will go to that very group, and it concerns us very much.

Mr. CRAMER. What other concerns do you have about the downsizing of NASA Headquarters?

Mr. ENGLAND. In any activity I think success depends, and particularly if it's a learning thing where we don't know all the answers, success depends on the competition of good ideas and good people trying to achieve things, and that's what we really mean by peer review.

As we transition program management for the science programs to the centers you run into a potential for conflict of interest. You have to make or buy decisions. Do we build it in house or do we send it out to a university to do this. You have decisions. Is the best investigator in my shop or is he some place or is she some place else.

It isn't that we know that these problems were going to occur—well I shouldn't say that we suspect that these problems can occur because historically NASA did manage its science in the centers, and it was the problems that that caused that moved the science management to Headquarters as strongly as it is now. Now that devolution back to the centers from most of our points of view has that same potential for problems we experienced before.

Mr. CRAMER. As you must know, there is an awful lot of concern out at the centers, and I'm speaking on behalf of the Marshall Space Flight Center about the practical impact of this downsizing and the delegating out of decisions and the programs, and we wonder if we're going to exist within the next five years.

Mr. ENGLAND. Yes, it's hard. I understand why NASA wants to do these things, but one of the things that will happen is that a program manager of a science program at a center will have a much more difficult time in coordinating the science across center boundaries. That has just been an historical fact in NASA, and the Headquarters leverage to do that is infinitely larger.

Mr. CRAMER. And of course in the process of that you can throw the baby out with the bath water.

I have nothing further, Mr. Chairman.

Chairman SENSENBRENNER. The gentleman's time has expired.

The gentleman from California, Mr. Rohrabacher.

Mr. ROHRABACHER. I would like to know if Mr. Weldon would like to ask a few more questions, and I'll be happy to yield my time to him if that's within the rules that the Chairman has established.

Chairman SENSENBRENNER. Absolutely.

Mr. ROHRABACHER. Mr. Weldon, do you have any other questions? I know that you have a particular interest in this area.

Mr. WELDON. I have a lot of questions for the other panelists, but I do have a question maybe that I could get an opinion on from Mr. Wisniewski.

In the zero base review moving the OMDPs from California to Florida, was that in that, or is that something that has come from some other place?

Chairman SENSENBRENNER. May I ask the gentleman from California if he still wants to yield knowing what the line of questioning is?

[Laughter.]

Mr. ROHRABACHER. Yes, I will yield to Mr. Weldon.

Mr. WELDON. The gentleman is truly a gentleman.

[Laughter.]

Mr. WISNIEWSKI. During the zero base review that was considered as an option and it was discussed, but no position was taken on it. It was left to the Shuttle restructuring activity and the contractor to come out with that conclusion. So the ZBR team did not take a position on that.

Mr. WELDON. Thank you. I yield back.

Mr. ROHRABACHER. I will yield back the balance of my time. Thank you.

Chairman SENSENBRENNER. The gentleman from Texas, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman.

Dr. England, I've been a strong supporter of the space life sciences, and especially of the biomedical research. Probably the reason I'm still in Congress is to follow that and to try to see that it's funded and see that it's operational and that it works.

Has the Space Studies Board examined NASA's life sciences and the biomedical research programs, and if they have what is your assessment of the programs? Are they alive and healthy?

Mr. ENGLAND. Again, I'm not a life scientist and I don't sit on the subcommittees that examine that. So my exposure is through listening and reading their reports either in review or in listening to them in the committee.

Mr. HALL. What have you heard?

Mr. ENGLAND. Well generally our perception is that the life scientists and life sciences have been on an upward vector and that they're healthier than they have been. We are very concerned about the change in management structure which may have the potential to retard that progress and, in fact, maybe even move it back to where it was before, where some of the life sciences at NASA were not anything to be particularly proud of.

We believe and many of our letter reports have stated that some very exciting science can come out of life science research on the Space Station, but to do that will take the participation of a broad community of very talented individuals, and we would very much dislike seeing, or we don't think it would be a healthy thing to see those life sciences draw back down into a very narrow group down in Houston. So that is our primary concern with the life sciences.

The microgravity sciences, there are a lot of interesting problems that need to be addressed and there are many people who would like to address them. Like all of science right now, there is a funding constraint, and I'm sure that community feels that it could use more funds constructively, but that's true across the board.

Mr. HALL. I don't know how much you listened to opening statements, but if you heard my opening statement I stressed my interest in the biomedical thrust.

Mr. ENGLAND. Yes.

Mr. HALL. I've attended all three of the major NASA facilities and in each place I've found physicians that were working with a biomedical reactor about this wide and this tall and yea long with cancer cells lapping up against the wall and white corpuscle cells with no really room to study in the type environment that is conducive to getting a breakthrough.

The American people have spent a lot of money on space and it seems to be a highly publicized, blue ribbon. Don't touch our finances entity forever, because of the high regard and respect that they had for it. But I think the American people are getting now to where they want a product out of space, and what better product could they have than a cure for cancer or a cure for one of the diseases or at least some indication that we were close onto it.

With the pharmaceuticals and the crystals and things you can produce up there in that weightless environment you've got a lot better chance, and for that reason I want to just be very careful every step of the way to protect the biomedical thrust in space. Otherwise I probably wouldn't support the Space Station, particularly after the President has redesigned it about five times.

Mr. ENGLAND. Yes, sir. I'm very aware of your support of the life sciences and it's very much appreciated.

Mr. HALL. I thank you, sir.

I yield back my time. Thank you, Mr. Chairman.

Chairman SENSENBRENNER. The gentleman from Texas, Mr. Stockman.

Mr. STOCKMAN. I just want to reiterate what my good friend from Texas, Ralph said. You mentioned a little bit ago about not keeping everything in Houston, and I want to tell you that I think you should look at M.D. Anderson and some of the research that's going on there and the commitment to medical research and space in Houston.

Mr. ENGLAND. I'm sorry, I mislead you in that statement. I didn't mean to any way impugn the medical research in Houston. I was speaking primarily of the institute that would support the Johnson Space Center that Johnson is creating.

Mr. STOCKMAN. Well I just want to say that Ralph Hall is very articulate and he's correct in the fact that we're looking forward to working with you and making sure that all things be equal and that Houston is not overlooked.

I yield back the balance of my time.

Mr. HALL. Would the gentleman yield there?

Mr. STOCKMAN. Yes.

Mr. HALL. All the things they can't do in Houston would it be okay with you if they did them in Clear Lake?

[Laughter.]

Chairman SENSENBRENNER. The gentleman from California, Mr. Brown is next up.

Mr. BROWN. Thank you, Mr. Chairman.

Mr. Brown has waived his rights to questioning by being so late, but may I ask unanimous consent to insert a brief opening statement?

Chairman SENSENBRENNER. Without objection.

[The opening statement of Congressman Brown follows:]

OPENING STATEMENT

BY

HON. GEORGE E. BROWN, JR.

APRIL 17, 1996

Good morning. I look forward to today's hearing and the opportunity to hear from a rather diverse set of witnesses. It is likely to be a lengthy hearing, so I will confine myself to a few brief remarks.

A theme that underlies a number of the issues discussed today is the impact of the budgetary outlook confronting NASA in the coming years. As you will recall, last year NASA was faced with the challenge of reducing its five-year funding profile by $4.4 billion. That challenge led to the Zero Base Review and a range of restructuring activities, some of which will be discussed by witnesses today. This year, NASA has been given a seven-year funding profile that, on paper, would require significant additional reductions, which I frankly do not think are sustainable without doing violence to the research and development capabilities and programmatic balance of the space agency.

It is small comfort to me to note that the Republican budgetary proposals would cut NASA even more deeply. In fact, it troubles me greatly that the Administration and the Republican Congress appear to be in an ill-advised and damaging competition to see who can cut the space program more. If we carry out either side's plan, I think we will come to regret our shortsightedness. It may not be possible for reason to prevail prior to the elections this fall, but I intend to continue to work to get NASA back on a more robust long-term budgetary path.

Thank you.

Chairman SENSENBRENNER. Mr. Kay, I have one very quick question for you as we're wrapping the panel up. Do you believe that we have now reached the law of diminishing returns on downsizing NASA and further downsizing will be counterproductive?

Mr. KAY. I think so for two reasons. One, the reason you just suggested, the diminishing returns, and there is another point I would like to stress, which is that I think that what NASA has done very, very well so far is to put this in a positive framework where this is being done according to a plan where from the day he got there Dan Goldin has been saying I want to remake the agency in this way with new technology, new ways of doing things, faster, better, cheaper, and when we get done doing this, we will be in compliance with the new way we want to have government look, and there is a limit as to how many times you can say that. So having an additional budget cut come down, it's difficult now to go back and say, okay, well we have to cut more money, but we'll still be better than we were before.

So I think that in addition to the diminishing returns argument and in addition to the loss of revenue this actually has some real credibility and even further morale problems of the proposed additional cuts.

Chairman SENSENBRENNER. This sounds like an endorsement for Mr. Goldin to become Secretary of Energy.

[Laughter.]

Mr. KAY. I'll reserve judgment on that.

[Laughter.]

Chairman SENSENBRENNER. Thank you.

The gentleman from Virginia, Mr. Davis is last.

Mr. DAVIS. No questions.

Chairman SENSENBRENNER. Thank you very much to each of the panel members.

I know we're covering an awful lot of territory in a brief period of time, but in order for us to have our input before the Budget Committee and the Appropriations Committee goes to town on the NASA budget it's important that we have this record as complete as possible. So I would like to personally thank each of you for the time and effort that you've put into preparing your testimony, coming here and answering our questions.

Thank you.

The second panel will be on Space Technology.

The witnesses are, first, Colonel Gary Payton, Director of the Space Transportation Division of NASA, second, Major General Lance Lord, Director of Plans of the Air Force Space Command, third, Dr. Rick Fleeter, President of AeroAstro and, fourth, Dr. Ray Morgan, Vice President of Aerovironment.

All of your prepared statements will be included in full in the record. Furthermore, I'm certain that there will be questions that some of the Committee Members will be asking you to reply in writing, and without objection your responses in writing will be included in the record.

First up will be Colonel Payton.

STATEMENT OF COLONEL GARY E. PAYTON, DIRECTOR, SPACE TRANSPORTATION DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Colonel PAYTON. Thank you, Mr. Chairman. I deeply appreciate the opportunity to address your Subcommittee on the RLV, the Reusable Launch Vehicle Technology Program and the Advanced Space Transportation Technology Program.

I have prepared a written submittal, and rather than summarizing that I would instead like to use this opportunity to bring your Subcommittee some information on the progress this program has made over the last several months.

To your left you see a picture on an easel that depicts the DC-XA. This is a bird that flew last summer out of White Sands, and in the intervening time we have taken that, formerly a DOD asset, we have taken that bird and totally retrofitted it with absolutely new technology in this past year. We chose to show this picture because it shows that technology before the exterior aeroshell was installed upon it.

Up on top the orange segment is actually the first flight demonstration of aluminum/lithium/oxygen tanks. This new tank weighs approximately 14 percent less than its predecessor tank.

Right below that orange tank is an absolutely brand new composite interstage that will actually carry the loads, the launch loads and the landing loads that are in the bird. This intertank weighs 44 percent less than it's aluminum predecessor that flew last year.

Below the intertank is a brand new completely composite liquid hydrogen tank that holds the hydrogen for the rocket engines. This tank has been completely tested, it does not leak, and it weighs 24 percent less than its predecessor. So we're showing this version, the interior view of the DC-XA to show how it is a completely new bird from the inside out even though when we see it fly in a few weeks the exterior will be identical to what it looked like last year.

We have not limited our technology demonstrations to these components. The current flow of an orbiter down at the Cape, a typical flow requires 17,000 man-hours to inspect, repair and waterproof the thermal protection system. These are the white tiles, the blankets and the black tiles that are on each orbiter. Seventeen thousand man- hours is approximately 400 people working a week. If we are going to have a truly operational, efficient launch vehicle we need to get a more robust thermal protection system on that bird.

I have here actual flight test articles that we flew on a pylon on an F-15 from Dryden just literally two or three weeks ago. The test program took a couple of weeks. On the left you can see the test articles that represent today's Shuttle tile technology, and on the right you see the tiles that we will be flying on the X-33.

The intent here was to prove the robustness of these thermal protection systems in rain. Today's Shuttle cannot launch through rain. It cannot enter the atmosphere through a rain cloud and cannot even fly through rain when it is being transported on the back of a 747. Again, we have to solve that problem. The component technology, these coupon samples were flown again on an F-15 at 300 knots through a rain shower, at 500 knots through a rain shower and the Shuttle tiles as predicted completely ablated, but the new generation of thermal protection tiles survived superbly. The 500 knot flight test through a rain shower actually ablated some of the paint from the skin of the F-15.

Additionally, on three Shuttle flights this year, two that have already flown, one in February and one in March, and then the next one in May, we are flying this thermal protection system in coupon sizes on the bottom of the orbiter and on the fuselage of the orbiter, but we are also flying metallic thermal protection systems. This will fly on the bottom down by where the tail connects to the fuselage.

This technology, as you might suspect, is very, very robust through the rain environment and handling on the ground. Its problem has historically been its weight, but we will be demonstrating in May a metallic TPS system that is as light as the ceramic TPS.

Chairman SENSENBRENNER. The gentleman's time has expired.

Colonel PAYTON. Yes, sir, fine.

[The prepared statement of Colonel Payton follows:]

Statement of

Gary E. Payton

Director, Space Transportation Division
Office of Space Access and Technology

before the

Subcommittee on Space and Aeronautics
Committee on Science
House of Representatives

Mr. Chairman and Members of the Committee:

I am pleased to be able to meet with you today to discuss the status and proposed budget of the Reusable Launch Vehicle and Advanced Space Transportation programs and the issues which face our nation's space transportation capabilities.

Mr. Chairman, we are facing a critical national space transportation challenge in the coming years. America's costs for space access consume so many resources including budget, talent, and facilities, that insufficient resources remain to undertake the bold, aggressive and exploratory endeavors that this Agency and our nation want and should be pursuing to advance our technologies and science. Many valid space missions, experiments, explorations, and commercial endeavors are not even planned simply due to high launch costs. To enable this Agency to conduct better, faster, and cheaper programs in exploration, research, and science, and to enable this country's commercial sector to flourish in space endeavors, we must significantly reduce the cost of space launch.

In addition, others possess competitive advantages that have removed this nation from its preeminent position in worldwide commercial launch capability. The U.S. commercial space launch industry has dwindled from complete market dominance in the mid-1970's to only 30% of the worldwide market today. This is costing the nation high-value jobs, international balance of trade, and a robust launch industry, and has resulted in this country becoming a second-place commercial launch provider.

The landscape of space launch is changing and we need to prepare accordingly. This situation is becoming increasingly evident as we prepare for the next millennium. We need to take significant steps to advance our launch technologies to allow future launch costs to drastically shrink, and to enable this nation to regain the technological lead in the space launch industry. Improvements to be achieved by the Evolved Expendable Launch Vehicle are fitting near-term measures which will moderately reduce launch costs. However, the vehicles' configurations remain essentially unchanged, and we are simply re-engineering conventional launch vehicles, thus these measures will not adequately address our long-term needs. Around the turn of the century, NASA will face investment choices regarding the Space Shuttle or an alternate launch system, such as an operational Reusable Launch Vehicle (RLV).

To dramatically reduce launch costs, we must take bold steps forward in both technologies and vehicle configurations. NASA has two roles in these endeavors. The first is to provide the technology base required to satisfy our long-term strategic plans for Space Science, Mission to Planet Earth, and the Human Exploration and Development of Space. The second is to perform the research and development necessary to enable the US launch vehicle industry to compete in a global market. The intent and goal of the Reusable Launch Vehicle (RLV) Technology and complementary Advanced Space Transportation programs is to develop and demonstrate the key technologies to meet these goals.

Through these programs, NASA and major US aerospace companies have embarked on a partnership that will position this nation to lead the world in low-cost space launch. We are using innovative methods from procurements to policy changes to permit this experiment to get underway.

The Reusable Launch Vehicle Program includes ground-based technology development and a series of flight demonstrators --- the DC-XA, the X-34, and the X-33. These flight demonstrators incrementally expand the technology and flight test envelope, provide a realistic environment to prove Reusable Launch Vehicle technologies, and demonstrate operability required for low-cost access to space. The RLV technology program will provide the necessary technology verifications to permit us to commit to a revolutionary new space launch system around the turn of the century.

Key new technologies are ready to be flown this spring in small-scale flight demonstrations on the advanced version of the DC-X, now referred to as the DC-XA. Over the past two years, in an industry-led effort with NASA and DOD participation, new technologies have been readied for use in this vehicle. For example, the first-ever, large-scale composite liquid hydrogen tank, together with composite fuel lines and valves, will fly this spring in the DC-XA. This will be a major flight demonstration and a significant advance in the use of composites for cryogenic applications.

While the DC-XA is an important step forward in revolutionizing the space launch industry, it is still only a subsonic vehicle. Our next step into a more demanding flight test environment is to be the X-34. The initial X-34 effort combined NASA's need for early technology demonstration with industry's need for rapid development of a commercially viable small launcher. Unfortunately, our industry partners determined that the economic viability of that program could not justify their investment and they withdrew. However, NASA's objectives for an X-34 technology demonstrator remain, and we are now in the process of redefining the X-34 as a pure technology demonstrator and a pathfinder for X-33.

The X-34 vehicle will demonstrate technologies necessary for a low-cost commercial vehicle, but will not be a commercially viable vehicle itself. This allows the X-34 vehicle to concentrate on flight demonstrations and close the gap between the subsonic DC-XA flying this spring and the 15,000-17,000 ft/sec X-33 flying in the spring of 1999. This has been, and remains, NASA's top priority objective for X-34.

With advanced technologies in such areas as propulsion, structures, reusable cryogenic tanks, thermal protection systems, and avionics, we are now postured to take the important next step to return the US to its preeminent role as the world leader in space launch. We are going to prove these technologies in ground tests and in large-scale flight tests on the X-33. The X-33 is an integrated effort to not only flight demonstrate key technologies, but to deliver advanced developments in: 1) propulsion, including a prototype engine, to reduce the development risk for the operational RLV engine and to prove the necessary operability; 2) lighter, reusable cryogenic tanks; 3) application of New Millennium micro electronics for vastly improved reliability and vehicle health management; 4) advanced Thermal Protection Systems to reduce maintenance; and 5) ground and flight operations techniques that will substantially reduce operations costs for the RLV.

We are proceeding to the flight demonstration phase (II) decision of the X-33 this summer and expect to meet the X-33 decision criteria that we agreed to with OMB and OSTP last year. The decision will depend on the progress of the technology in Phase I, an independent validation of this progress, and the quality of proposals we receive from industry. Recently, the Technology and Commercialization Advisory Committee (TCAC) of the NASA Advisory Council (NAC) reviewed the progress that we have made in meeting the OMB/OSTP Phase I exit criteria. Their findings will be reported to the NAC later this month for its consideration.

The final X-33 Non-Advocate Review (NAR) will assess the adequacy of current program definition maturity to meet program objectives on schedule and within planned budget. Scheduled to be held in mid-May, its findings and recommendations will be presented to the NASA Program Management Council in June. The X-33

Cooperative Agreement Notice (CAN) was released on schedule April 1, with proposals due on May 13. A detailed source evaluation process and schedule have been developed to permit a selection in late June. We plan to initiate Phase II on July 1 using FY96 monies that are being held pending White House approval. In FY97, $251.1M has been proposed to continue this next phase of the RLV Program. The Phase II decision is not a foregone conclusion. We are willing to say no if NASA and industry are not ready. Nevertheless, we are on track to meet the challenge of X-33.

The Advanced Space Transportation (AST) program will focus on technological advances, not addressed by the Reusable Launch Vehicle program, that have the potential to dramatically reduce the cost of space access. The AST program consists of three key elements; (1) advanced reusable propulsion technology, (2) small payload launch technology, (3) and advanced space transfer technology.

To make the cost of space transportation operations approach that of today's airlines, performance margins will have to be increased. Increased performance margins will allow longer life and reduced maintenance of reusable systems. Advances in reusable propulsion systems are key to providing this performance margin but are higher risk than those being considered for the X-33 and require significant technological advancement. The first key element of the AST program will pursue these technologies. Propulsion technologies that hold tremendous promise for the next generation space transportation systems include combination air-breathing and rocket propulsion and rocket-based combined cycle propulsion which uses air as augmentation to the rocket propulsion. A small improvement beyond today's state-of-the-art engine can have a significant effect on the operational efficiency of a low-cost RLV. The focus of this activity is development and ground test of critical combined cycle components by 1997. Even if these systems do not mature in time for inclusion in the operational RLV, investment in this area is crucial to prepare for the future of space transportation.

The second AST program element focuses on a segment of NASA's launch requirements not addressed by RLV. This requirement consists of dedicated vehicles capable of launching payloads in the range of 500 pounds or less to Low Earth Orbit at a fraction of today's costs. Small payload launch technology investments are intended to enable commercial development of launch vehicles that will dramatically reduce launch costs for these missions and other government and commercial users. The focus of this element is to allow utilization of non-traditional suppliers, commercial parts and commonality among components to realize production rate cost advantages. Investments will be made in innovative design for low-cost manufacturing and systems engineering which will lead to space transportation hardware that does not require the highly specialized, labor-intensive manufacturing and operation of current space transportation systems. Technology demonstrated by this element of the program will also have direct application to the RLV and other elements of the AST program. The focus of this effort is development of a ground-based technology test bed by 1997.

The third key AST element targets technologies that increase the efficiency and reduce the cost and trip time of current orbit transfer systems. Space transfer systems which increase transportation efficiency by more than a factor of two are achievable within the next five years. Payloads requiring delivery to geosynchronous equatorial orbit could be launched by smaller, lower cost launch systems or share space with other payloads on larger launch systems. Reduced trip times will shorten the time teams will be required to remain in place to execute missions. Exploration initiatives like the New Millennium Program are focused on miniaturizing spacecraft, but the cost advantage will not be realized unless the spacecraft propulsion reaches efficiencies which allow order of magnitude reduction in size and mass. The focus of this effort is a solar thermal propulsion demonstration in orbit by 1998.

We must ensure that we strengthen our resolve to complete the technology development and demonstration required to make informed decisions around the end of the decade on whether or not to pursue an operational RLV. Like our aviation industry, we can envision a time when US-manufactured low-cost RLV's will be operated by multiple spacelines, both national and international. This is our vision. Let's roll up our sleeves and not simply put a low-cost RLV in operation, but also commit this nation to focus on a strong and long-term technology program that will strengthen our leadership in this vital international arena.

Thank you, Mr. Chairman, for the support of this Committee. We are ready to work with you in every way to advance this vital national effort.

SPACE ACCESS AND TECHNOLOGY
FY 1997 PRESIDENTS BUDGET REQUEST

	FY 95	FY 96	FY 97
ADVANCED SPACE TRANSPORTATION	**162.1**	**188.5**	**324.7**
RLV - SYSTEMS ENGINEERING & ANALYSIS	3.8	0.5	0.0
RLV - TECHNOLOGY PROGRAM	75.5	49.5	0.0
RLV - INITIAL FLIGHT DEMO PROGRAM (FDP)	49.2	109.0	266.1
ADVANCED SPACE TRANSPORTATION TECHNOLOGY *	0.0	0.0	42.0
TRANSPORTATION TECHNOLOGY SUPPORT	33.6	29.5	16.6

* Advanced Space Transportation Technology efforts are also supported by $15 million in FY 1996 and $12 million in FY 1997 funded within the Engineering and Technical Base program of the Office of Space Flight.

Chairman SENSENBRENNER. General Lord.

STATEMENT OF MAJOR GENERAL LANCE LORD, DIRECTOR OF PLANS, AIR FORCE SPACE COMMAND

General LORD. Thank you, Mr. Chairman and distinguished Members of the Committee. It's my pleasure to be here today and kind of share with you what I think are some good views on the mutual relationship between the Air Force and NASA and how that is expanding.

A little over a year ago our Chief, General Fogelman and the Administrator of NASA got together and talked about how we could enhance cooperation and coordination better between the two organizations. General Fogelman hosted a DOD/NASA dinner in August of 1995 to further explore that, and in the dialogue that emerged afterwards an agreement was reached to establish seven integrated product teams, IPTs if you will, under the auspices of the Aeronautics and Astronautics Coordinating Board.

Those seven IPTs that we're involved in to a great deal cover technology in laboratories, space launch, satellite telemetry, tracking and control, major facilities, personnel exchange, base center support and services and interagency agreements. Each IPT is coled by a senior NASA and DOD official, and the established goal for each of the IPTs is to minimize redundancy and maximize the sharing of programs, facilities and expertise.

Each is tasked to make recommendations in the following areas. How we can better leverage science and technology investment; how we can streamline our operation costs; how we can consolidate redundant facilities and share dual-use facilities and support services; and how we can reduce personnel costs overall.

The final reports of each of these IPTs is due the 29th of April, this month, and the IPTs will then do the transition and set four permanent standing panels to take a look in aeronautics, space operations, launch system development and spacecraft technology.

These IPTs have already identified and helped us harmonize technical planning, and as a key result have suggested that a major thrust be to continue to focus on this in the future. This game plan will provide both DOD and NASA the unique opportunity to establish long-term relationships that can optimize the resources available to both organizations. This is a mutual priority and one I can promise you that we're going to work hard and continue to work aggressively.

The results to date show that the Air Force's technology planning process is amenable to immediate NASA participation and that NASA and the Air Force processes can and should be more closely tied to one another. This cooperation will extend to NASA memberships on all our space technology planning teams in the Air Force Space Command, the Space and Missile Center at Los Angeles and also our Phillips Lab.

Right now we've got some long-term personnel exchanges that have already been consummated, and I have in my organization at the Air Force Space Command Mr. Stan Goldberg that works in our planning and programming area. Mr. Michael Moore from NASA works at the Space and Missile Center, and Mr. Gary Neubrough at Phillips Lab will come on later this summer. My boss, General Joseph Ashy, the Commander of Air Force Space Command, and also Lt. General Lyles, who is the Commander of the Space and Missile Center at Los Angeles and then Colonel Heil, the Phillips Lab Commander, all fully support this. So we've got NASA key senior people at good places in our Air Force organization.

In addition, last week Mr. Goldin and General Ashley met as part of a session related to the United States Space Foundation meeting in Colorado Springs, and we're going to place an Air Force senior officer in the Reusable Launch Vehicle Office to help further coordinate. So our integrated technology planning processes are working and modeled together in a great way, and that certainly is helpful for us.

We intend to continue to expand the Joint Space Technology Development and Demonstration Programs. Space, power, communications, electronics and satellite command and control are pervasive needs that we both share and they provide significant opportunities for extensive cooperation and cost sharing in the future. Currently the Air Force Space Command's Integrated Space Technology Demonstration Program is leveraging NASA's Clark satellite and they're programmed to the benefit of both organizations.

In summary, I think we've come a long way very quickly. There is much more to be done and personnel exchanges will continue to provide each organization with the right kind of people in the right place to help us to continue to coordinate.

Thank you, sir.

Chairman SENSENBRENNER. Thank you, General.

Next up is Dr. Rick Fleeter, President of AeroAstro.

Dr. Fleeter.

STATEMENT OF RICK FLEETER, PRESIDENT, AEROASTRO

Mr. FLEETER. Hi. I'm glad to be here to speak a little bit on the value of the emerging technology of micro-satellites.

Over the last 18 or 19 years I've been involved in developing about 25 of these tiny satellites, some of which are small enough to fit inside of this pitcher, and a few large satellites. Maybe the interesting fact about that is that if I had done 25 large satellites and a few small satellites I would have to be about 400 years old to be saying that.

So there is one large difference between small satellites and large satellites which is the speed which you can bring them to market, and that speed translates into a lot of important things. There is a relevance to the mission. You can get the mission done while the science is still important and while the people in it are still interested in it. Students build these satellites and they finish them while they're still students and there is a return on investment. If a company wants to do something in space they don't want to see it happen 10 or 15 years from now. They want to see it happen before the cost of the investment that they've made has gotten out of hand.

Small satellites are like a lot of things. They're like PCs, personnel computers in one sense, which is that they're very cheap. So a lot of people can do them and you put the technology in the hands of a lot of people, and by doing that with students, commercial companies, research labs and individual scientists and hobbyists you create a fertile ground for innovation. The reason that they're cheap is that they're small and they're simple.

I watched Dan Goldin doing the best job that I think anyone can do doing very complex and expensive things as cheaply as possible, and it reminds me of the fight that went on for many years in mainframe computer companies like IBM to make mainframe computers cheap, and they did a great job. They made them four times cheaper, but that didn't revolutionize the world, that four times cheaper. What caused the revolution was computers that costs a thousand times less than mainframe computers or ten thousand times less, and that's what we're talking about in small satellites, things that cost .1 percent or .5 percent of the cost of a normal conventional satellite. So we're talking a hundred thousand dollars to a million dollars or a couple of million dollars.

In my mind the NASA road sort of leads you to constantly drive for less labor, lower labor costs, finding ways to get difficult things done cheaply, which sort of like ends in this was made in the Philippines, or this was made in Russia, or we go and find some place where people will work cheap, or we just overwork engineers and keep trying to drive labor costs down. The micro satellite approach has been to leverage technology, keep design simple, keep the labor content simple and earn your reliability that way.

In the applications area Apollo was fascinating. I was a little kind when Apollo happened and the moon landing happened, and I have to say that following my computer analogy INEAK[sic] was fascinating, too, as a big computer, but it's not fascinating any more. It's not fascinating to my generation and the next generation of people who work at my company. It's a little bit like reruns of television shows from when your parents were your age.

There is new stuff that you can do in space. There is an infinity of things that you can do in space, and it's a matter of choices, what do you want to do, and people get interested in doing something new and not in replaying that same Person in Low Earth Orbit tape over and over again. I just listed a few of these things.

One of them is on demand launching of satellites. When you need them you launch them. So you don't keep armadas of capability in space and then hope to use it sometime if you need it. You can launch on demand and do the things that you need to do. You can provide a private satellite service. If a company decides they need a sensor to look for oil or gas or minerals, then you launch that satellite. You don't say to them, well we have a resource and we hope it's valuable to you.

You can do things like instant global forest fire detection because with a group of small satellites you can see the whole earth simultaneously all the time, and you can do things in the science area, too, like robotic exploration of the lunar surface. We went to the lunar surface for basically a few minutes to a few places. But with small satellites deploying robots you can stay on the lunar surface for days, weeks, months or years and really rove the whole surface and see things that we haven't already seen before.

So these things are not better, and I don't want to sit here and say these are better things, but they're new things that we haven't done before and they bring a certain excitement and a certain relevance to space that I feel like is lacking.

I'll just finish up with one other remark, which is I feel that micro-satellites like little computers, and I don't want to drive this analogy too hard, are a distinctly American kind of thing to do because for one thing they cope with a problem that the rest of the world hasn't coped with yet, which is technology changes very fast in 1996, and you can build these satellites very quickly and use that new technology very rapidly.

Chairman SENSENBRENNER. Thank you very much.

[The prepared statement of Mr. Fleeter follows:]

AeroAstro

Written Statement
prepared for

US House of Representatives
Committee on Science

regarding hearings on
Fiscal Year 1997 NASA Authorization
specifically addressing

Benefits and Capabilities of Small, Low Cost Spacecraft and Missions

by
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April 17, 1996

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Rick Fleeter

Dr. Rick Fleeter is a founder and President of the small satellite and space transportation company AeroAstro, and the International Small Satellite Organization (ISSO). He has been responsible for development of 25 miniature satellites ranging from 2.5 to 250 pounds (see attached summary sheet) and has been writing and publishing the New Space (previously ISSO) newsletter bimonthly since 1987. At AeroAstro, which he co-founded in 1988, Rick originated programs totaling over $15M. He authored the only book on the technology of small satellites, Micro Space Craft, as well as the small satellite chapters of the two most recent major textbooks on spacecraft engineering.

Rick was previously the Director of Space Technology at Defense Systems Inc., where he was the program manager and/or a lead engineer for programs totaling 15 satellites. He originated two major programs totaling eight new satellites and creating over $4M in sales. From 1983 through 1986, Rick was a Project Engineer at TRW Space and Technology Group where he originated, marketed and performed research and development programs on aerospace propulsion systems and laser applications in combustion. Rick received a commendation for his contributions to the successful rescue of the $150M TDRS-1 communications satellite and was awarded a patent for propellant additives which resulted in a major government funded program. Prior to joining TRW, Rick was Senior Scientist at Jet Propulsion Laboratory, Caltech, where he participated in the Mars mission and space station advanced designs and pursued research in spacecraft and aircraft propulsion. Since 1979, Rick contributed to AMSAT, the world's most experienced small satellite organization. He was AMSAT's program manager for propulsion on the PACSAT communications satellite program.

In addition to his book, chapters within two others, and newsletter, Rick has authored numerous papers on thermodynamics, propulsion and small satellite design and program management. As Adjunct Professor of Engineering at UCLA and Cal State Long Beach he taught undergraduate and graduate courses in thermodynamics theory and application.

Rick is a member of AIAA, Sigma Xi, AIP, APS and AMSAT. He lives in Reston, Virginia with his wife, Nancy, who is the Financial Controller of the John F. Kennedy Center for the Performing Arts in Washington, DC.

Small Satellite Development Experience Summary: Dr. Rick Fleeter

Satellite Name	Mass (pounds)	Number Launched	Launch Date	Mission	Cost $ each	Outcome
Oscar 13	250	2	1979	Communications	$100,000	1 Launch Failed 1 Successful
GLOMR	150	2	1982	Military Comms.	$1M	Successful
CRO	150	3	1988	Chemistry in Low Earth Orbit	$500,000	Successful
Stacksat	200	5	1988	Military Comms. Surveillance	$1.5M	Successful
Microsat	50	7	1989	Constellation Communications	$550,000	Successful
ALEXIS	220	1	1993	X-Ray Astronomy	$3M	Successful
HETE	225	1	1996	Astrophysics	$5M	Yet to launch
TERRIERS	220	1	1997	Earth Environment	$4M	Yet to launch
Bitsy	2	3	1997	Communications Remote Sensing	$200,000	Yet to launch
Total # of Satellites:		**25**		**Total Cost:**	**$25.7M**	
		Average Cost Per Satellite:			**$1.1M**	

Some History:

The first satellites were of necessity small - the first US and Soviet launch vehicles could put only twenty to two hundred pounds into orbit. A computer less powerful than the ones now powering greeting cards that hum happy birthday and flash little lights, in those days filled a building. Thus the capabilities of a small satellite were limited. But by 1960 useful satellites were launched weighing less than the smallest televisions of that day - about 100 pounds. Early satellites performed crude earth imaging, transoceanic voice and television relay, and space science. In the early '60s, several small satellites were built by amateur radio hobbyists, and several of today's satellite builders, myself included, first became interested and familiar with space technology through these amateur programs.

America's national focused shifted to large satellites for several reasons. The revolution in microelectronics had not yet occurred and sophisticated functions required a large satellite. American space and missile competition with the Chinese and Soviets favored support to ever larger rockets. There was, and remains, strong emotional appeal of crewed missions, which require the largest space systems. Popular science fiction including the book and film 2001: A Space Odyssey, popularized the romance of gigantic human structures in space. But activity continued in amateur and some scientific small satellites. Small satellites usually rode to orbit "piggyback" on the large rockets, flying in place of ballast and occupying unused niches within the launch vehicle's fairing. There were several early demonstrations of commercial small satellite applications such as Bell Laboratories' Telstar. Telstar was to be flown in constellations of many identical satellites. But the pressures in favor of larger, more complex, geosynchronous satellites, including justification of our efforts toward the crewed lunar landing and for creating a credible capability of launching heavy clusters of nuclear ICBMs made individual, much larger spacecraft more attractive.

By the mid to late '60s, mainstream space was focused on ever larger spacecraft. It was a major triumph of the engineering of that era to achieve a reliable spacecraft of such size (up to 10,000 pounds) and complexity. This was the fundamental contribution of aerospace engineering - pioneering the organizational systems required to build huge, complex and expensive systems of unprecedented (at the time) reliability. To pursue small satellites, by 1970, was then like advocating analog, vacuum - tube based electronics today. Small satellite enthusiasts were considered amateurs and Luddites, and our projects were pursued mainly by amateurs, students and countries without the resources to pursue space programs competitive with those of the superpowers - Japan, for example, pursued a vigorous science and education program exploiting small satellites.

By the early '70s, the microelectronics revolution was well underway and the first microprocessors were being used terrestrially. Several of us in the amateur satellite community realized that we could now build more overall capability in a small satellite of, say, 50 or 100 pounds, than the largest satellites of only a few years ago. Granted, large satellite capability was growing too, but we reasoned that if some application justified a multi-ton satellite in 1967, that application might still justify a 50 pound satellite in 1972. Moreover, small satellites in low earth orbit can do some things that large satellites at geosynchronous orbit cannot do. Amateurs pioneered so-called store-and-forward communications. A single low orbiting small satellite carried electronic mail messages all over the earth. Amateur radio operators pioneered an internet-like service for their community, and used it for experimentation with digital messaging, for civil defense and for communications support to humanitarian missions. We were building useful little satellites. They costed under $100,000 because they took just a year or so for a small team to build and launch. Our rapid development time, and lack of formal oversight, allowed us to fly the latest technology, simplifying the design and development process and further contributing to low cost. Launched with components only a year or two old, compared with the ten to twenty year old technology typical of larger satellites and their long development programs, these amateur satellites were more advanced in some respects than the large satellites whose rides to orbit we piggybacked on.

The amateurs were not totally alone in honing the technology of miniature spacecraft. There were DoD missions done by Naval Research Laboratory and at contractors. But my interpretation of what happened is this. The amateurs had no choice - without money, small satellites were all we could afford to build, and all we could find a way to launch. The government had the option to spend more if necessary to ensure a mission's requirements were fulfilled. And staying small has little constituency - it isn't impressive to the public, and it was counter to the government client's desire to hone the skills of mammoth space operations, and staying small and inexpensive may include giving up some capabilities. It is more efficient for both the supplier and client to manage a smaller number of larger programs.

Just as American cars of the '60s and early '70s grew larger and more luxurious, so did most of our satellites. And as long as money was plentiful for these gigantic missions, there was little impetus to question our single national direction. Small satellites under mainstream support had a fate similar to the Thunderbird or Nash. They either became large, or they disappeared. The lack of diversity in American automotive engineering only proved a liability when the energy crisis changed the competitive environment. The market dominance lost while our manufacturers slowly adapted to a changing market has never been recovered.

Similarly, big satellites have certain voids in their capabilities. Because of the sheer number of parts aboard, they are more failure prone than small satellites. They were reluctant to use the marketplace's most advanced components, including high speed, high density memories and power efficient microprocessors, preferring custom built devices. These space-application specific ("Space Qualified") parts, without benefit of the mass market, are generally more costly, larger, heavier, require more power and have longer lead times than commercially available parts. Smaller, simpler and intrinsically more reliable small satellites at the same time could achieve comparable or better reliability using the most advanced commercial parts. Long parts leads times and the large satellite's complexity mean they have very long development time typically ten years instead of one or two for small satellites.

The amount of money at risk in each large mission further emphasized the necessity of reliability. Small satellites were taking risks and innovating, using the latest microelectronics, integrating emerging commercial technologies onto spacecraft, and eliminating many of the high cost elements of conventional satellite development. And we small satellite developers are getting away with it. With about 30 amateur satellites launched, their reliability record is near l00% - better than the large conventional satellites.

Pretty soon, some of us members of the amateur satellite community were being employed as consultants to companies with plans to exploit miniature satellites for commercial and DoD applications. Most of the leading small satellite organizations of today, CTA, Orbital Sciences, AeroAstro and Surrey Satellite Technology Ltd, all leveraged the amateur technologies and employed leaders from the amateur community.

Today, we have a state of diversity in the space community much broader in scope than ever in our history. The large satellite heritage is carried forward in the Shuttle, Space Station, the major communications spacecraft built by companies like Hughes and Loral, and the great mission spacecraft like Hubble and AXAF. These satellites often weigh over 10,000 pounds. A scaled down version of this conventional approach is evident in what are referred to as small satellites but which I would characterize as small-large. Lewis, Clarke, Iridium, NEAR, Clementine, Odyssey and Globalstar use spacecraft much smaller than the Hubble and geosynchronous communications class, typically less than one ton, but still costing tens to hundreds of millions of dollars each. The room for innovation is still quite limited in this class of mission. At the opposite end of the spectrum are the ongoing amateur programs, many of them happening at universities like Stanford and Weber State (Utah), NASA's small programs like HETE and the STEDI missions with budgets of $4M to $l2M, LANL's ALEXIS and the Air Force's Mightysat and MSTI programs. These small satellites typically weigh under 250 pounds, and can be as small as two pounds. Each of these spacecraft species is finding specific mission and client niches which they are servicing better than any competing technological approach.

Why Big Satellites?

To answer the question "Why small satellites", it's easiest to answer the question "Why big satellites?". Some small satellite enthusiasts have asserted that they can offer a replacement for large satellites. In some cases this may be true, but the most significant applications of small satellites, like the early personal computers, has been in new applications which the technologies of conventional large satellites cannot address. Technological progress is allowing smaller spacecraft to tackle a larger scope of missions, but many important space missions still require large satellite technologies and capabilities.

There are an unlimited number of activities we can consider carrying out in space including: crewed exploration of the planets; robotic rovers on the moon; earth resources surveying from space; a huge spectrum of astrophysics research from Gravity Probe B to characterizing gamma ray bursts; educational activities in space science and technology; communications ranging from direct broadcast television to minimum cost digital mailboxes and messaging; and DoD missions ranging from high resolution large area imaging to selectively available GPS. Some of these are strictly accessible to large spacecraft technology, some clearly best handled by single or multiple miniature satellites, and some could be handled in a number of ways which can be traded off based on cost or political criteria. The question is not big vs. small but rather what do we want from space. Technology is the servant, and shouldn't be the master.

Small satellites, which I define as those which can be built in less than two years by less than twenty team members, cannot accomplish ambitious interplanetary missions like Voyager or Great Observatory missions like AXAF. Their technology is not appropriate for human presence in space except in support roles. Current technology does not yet allow us to link multiple miniature satellites into very large aperture coupled arrays, except in some special applications, so Hubble class telescopes require either conventional satellite approaches or adaptive optics located on the ground.

But these arguments mimic those against the PC of twenty years ago. The PC was not appropriate for the applications which had been developed for the giant IBM 360 and PDP-34 machines. Naturally, building-filling computers were set to doing things appropriate to what they could do. But as PCs became available, people found new things to do with miniature computers that we did not do with the old dinosaurs. Gradually our way of using computers changed to those activities PCs could do well: word processing; spreadsheet analysis; networking and communications (including the internet); small business management; entertainment; education; page layout, graphics and publication; engineering design and analysis; machine control and automation; music production; in-situ data acquisition. Large machines now occupy the arcane niches: data processing centers for large organizations; highly sophisticated scientific modeling; control of large networks. Now even these niches are under attack via networks of small computers whose power can be harnessed toward more complex tasks.

Similarly, the world of space activity appears to be focusing more and more on the applications small satellites can do: personal mobile communications; university research in earth science, planetary science and astrophysics; specific surveillance activities; GPS access denial; rapid development of new surveillance sensors; environmental monitoring and so on. It is not that there are no applications for which conventional satellites are better suited. Rather, the low cost, quick schedule, lowered risk, greater flexibility, ability to leverage the latest technologies in a rapidly evolving field and enhanced survivability of small satellite systems is motivating people to focus what we do in space on those activities well serviced by smaller spacecraft. Society's appetite for mammoth undertakings requiring decades of continuous funding is waning. The accelerating pace of technological progress favors multiple small missions which can be completed before they reach obsolescence or before their results are surpassed through alternative terrestrial approaches. And as with PCs, we are now beginning to combine networks of small satellites which will compete even for the niches currently filled only by major, conventional technology spacecraft.

One motivation for transitioning from mainframe to PCs was the ability to focus the computing resource on one specific application, a very difficult feature to achieve with mainframes built to share service among hundreds or even thousands of users. A very similar conflict makes small satellites desirable. Large satellites must often support myriad different on-board instruments and features. Each may require its specific thermal, electrical and magnetic environment, and may wish to be pointed in a specific direction, or to scan through a particular arc. The competing demands of the payload members must be arbitrated and compromised on a large satellite which, for example, cannot point in many different directions at once. In contrast, each one of multiple small satellites can be tailored in design and operation to optimally satisfy the requirements of its single primary payload.

Big vs. Small Space Comparison

I have mentioned several analogies: the large American car of the early '70s vs. the Toyota Corolla and VW Beetle; mainframe computers vs. PCs. And there are others - high fidelity sound of the '60s and '70s was mostly enjoyed using stacks of components and large speakers. Nowadays most consumers enjoy music via a handheld Walkman and personal headset, or from their car stereo. The sound quality is comparable, and portability and low cost have altered the balance of consumer preference. The factors people consider in selecting small vs. large satellites are no more subtle or complex.

Cost: Small satellites typically cost less than $10M, sometimes as little as a few hundred thousand dollars. Large satellites are $50M to over $1B.

Development Time: Small satellites can be launched in under a year, and rarely more than three years from program start. Large satellites typically require 7 to 20 years for development and launch.

Team Structure: Small satellites are developed by a highly interactive team consisting of roughly 20 or less members. Large satellites require a more formally organized management structure which can employ thousands or even tens of thousands of contributors. The small satellite skunkwork will be 90% to 95% occupied with the technical work which is its purpose, whereas the communications overhead and reporting requirements necessary to orchestrate a larger program results in a large fraction, often the majority of program dollars, being spent on management, meetings and paper generation. Small programs are a more effective way to turn dollars into technical work and innovation.

Technology: Small satellites have a small number of components. Thus the reliability of each component can be lower to achieve the same reliability as large satellites. Small satellites tend to use the most advanced components available, and frequently leverage COTS (commercial, off the shelf) technologies which benefit from the large investments justified by a mass market. Large satellites focus on parts with long heritage in space and are somewhat handicapped by slow adoption of new technologies. The Shuttle until l993 flew with less on-board memory than a hand calculator (several kbytes) while typical home computers had thousands of times more memory “on board”.

Infrastructure: Large satellites require large facilities. The US has only a handful of facilities, virtually all owned and managed by major contractors. Because of the small number of facilities and the small number of satellites, capital costs are a major component of spacecraft costs. Small satellites often require virtually no special facilities. Some of the most useful small satellites have been integrated in garages and on basement pool tables. Capital costs are not a significant consideration for small satellites. When complex facilities are required, the small satellite is put in a shipping container and carried in a car or as hand luggage on a commercial aircraft to any convenient and available test site.

Developers: Large satellites are developed by the small cadre of major contractors. Small satellites are developed by a diverse group including many of the National Laboratories, the Air Force, Navy and NASA, many universities, large and small companies and amateur groups.

Launch: Large satellites require dedicated launches on large launch vehicles including Titan, Delta, Shuttle, Long March, Ariane and Proton. Small satellites can be launched on small dedicated launchers like Pegasus and START, but more often are carried piggybacked on large launches of opportunity, often in place of ballast. Satellites are information machines, and information technology’s breathtaking advances are so fundamental that they continue to reshape our entire society. Rockets, by contrast, have not undergone a major evolutionary advance. Today’s rockets have cost and performance not very different from those of 30 years ago. But by shrinking the satellite payloads, small satellite developers are able to achieve dramatic cost savings despite relatively unchanged per pound transportation costs.

Nonetheless, a small rocket can benefit from many of the efficiencies already achieved in small spacecraft. A rocket tailored to small satellite payloads, providing the schedule reliability, orbit insertion flexibility and elastic manifesting capacity can be built with launch costs of $1M to $3M. NASA should strengthen its commitment to such a program. Our company has already demonstrated many of the key technologies for this achievement, and we, like some others in our field, are confident we can bring these technologies and techniques together to provide the transportation small satellites demand at a price comparable to the satellites themselves.

Geography of Technology: Like PCs, small satellites are a distinctly American innovation. The rest of the world still considers the large, complex and visually impressive symbols of space, large rockets, the Shuttle, the Space Station and large satellites, to be the ultimate symbol of technological prowess. And Europe, Japan and emerging aerospace competitors, particularly Korea, Taiwan, Russia, China and Israel, are tightly focused on winning large satellite business. They may be following the highly successful model of the French Arianespace, which now earns more revenues in commercial large satellite transportation than all other carriers combined.

Small satellites are being pursued in many countries including Great Britain, Israel, Russia, Spain, Germany and Korea, but mainly as a precursor to, a training aid toward progress into large spacecraft. Virtually all of the innovation in small space is in the US - missions like ALEXIS, HETE, Starsys, Iridium, Globalstar, Clementine and MSTI, have no equivalent outside the US. The same cannot be said for any large space initiative. The Russians built, though could not afford, a Shuttle, and have had a space station for years. Many countries build large geosynchronous satellites and the rockets to launch them. By contrast Orbital Science's Pegasus is the only currently operational only rocket in the world developed expressly to launch payloads under 1000 pounds. Its only existing competition is from converted Russian START missiles and our own converted Minuteman missiles.

Missions:

Communications: Small satellites can be launched in large numbers and used in networks similarly to the terrestrial cellular telephone network. Or they can provide paging and messaging services via individual satellites. Large satellites typically occupy orbital slots at geosynchronous where they appear to “hang” over one location which they service like a terrestrial cable television or telephone network. Small satellites are leading in mobile communications and low cost ground terminal applications (monitoring, paging) while large satellites are well established for direct broadcast television and point to point communications of huge amounts of data, for example for television network intercontinental links

Science and Technology: Large satellites tackle the most ambitious missions like the Voyager explorations of Saturn and Hubble. Small satellites tend toward single objective missions, many of which can be done from earth orbit. These include geophysics, astrophysics, particularly all-sky monitoring, and demonstration of new technologies like electric propulsion and new sensors.

Defense: Large satellites are necessary for very high resolution imaging of large portions of the earth surface. Many surveillance applications require large apertures and fine pointing best provided by large spacecraft. Small satellites are currently mainly used for technology development, but ultimately will be used for jamming, for examination of space activities of others, for rapid, event-driven deployment based on need, rather than maintaining large infrastructures which are over adequate except at crisis times when they are inadequate. Small satellite constellations will become the dominant communications mode because they are intrinsically resistant to serious degradation and outages via antisatellite measures.

The promise of small satellites

Small satellites in 1996 are about where small computers were in 1976. We have built enough of them to demonstrate some interesting potential and to generate a cadre of dedicated supporters. Small satellites are a disruptive technology - the conventional developers of large space systems can be expected to defend their products by pointing out perceived deficiencies in the ability of the disruptive small spacecraft element in doing conventional missions. But the market, the client base, is ultimately impressed by utility, not arguments. Apple, Microsoft, Compaq and Dell blossomed providing disruptive microcomputer technology to a burgeoning market, while IBM and DEC faltered and giants like CDC disappeared. Unfortunately, in space most of the market is also the supplier. NASA and the Air Force, a combined aerospace "market" of over $30B per year, are heavily invested in large spacecraft and the types of missions for which they are best suited. Their organizations feel threatened by the possibly inevitable sea change. And they understandably are working to slow any disruptive transition.

But ultimately budget pressure and the intrinsic value of the miniature satellite technologies will increasingly move our space activities toward smaller and smaller hardware. Our tastes in space missions will co-evolve. Some missions we can expect to realize with small satellites are listed below.

- Mobile communications: Small satellite programs including Iridium, Globalstar, and Teledesic may ultimately replace, or at least compliment, the terrestrial communications infrastructure. Any location on earth will have access to very wideband communications services including email, telephone, television and internet services. This will speed the trend toward decentralization and telecommuting, but more importantly, it will remove a major impediment to international development. Lack of a communications infrastructure will be a much less important factor in national and regional development. Some of these next generation large communications networks are already in development.

At the same time, very simple communications networks will emerge servicing small, individual markets. These are the “taxi radios” of small space. Just as many PCs are used alone without connection to the Web, individual small satellites can provide company-specific or region-specific basic communications services. This application has already been demonstrated and new commercial services are in development.

Small satellite networks can provide wristwatch communications capability. A personal emergency beacon can be integrated into the wristwatch to summon help immediately, providing the distressed individual’s name and location to rescuers from anywhere on earth. This technology is already being designed into automobiles to disable them in case of theft and even to allow the factory to unlock the car remotely should you lock your keys inside.

- Space Exploration and Space Science: Small spacecraft are highly mobile. They can more economically place robotic rovers on planetary surfaces like Mars and the moon. In place of great missions to a single spot, as we accomplished with Apollo, our robots will spend a long time on a planet exploring a much wider area in much more detail. Small spacecraft will be put in orbit around planets and moons to provide communications and geopositioning services for our probes. Micromachines will allow extensive chemical analysis of surface and subsurface materials in the search for traces of life and for resources. Robotic rovers and the agile spacecraft to deposit them on planetary surfaces have both already been demonstrated.

Networks of small satellites will be used in arrays, providing much higher sensitivity and resolution than possible with individual large aperture instruments. Radio astronomy, which has recently identified planets around other star systems, will achieve breakthrough instrument performance through these space-based arrays.

Capitalizing on their mobility, small satellites will be used to populate strategic scientific outposts in space. These include the LaGrange point sunward from earth from where we can be warned in advance of solar storms which disrupt electric power distribution and communications on earth. A network of small satellites will be strung along earth’s orbital path all around the sun for continuous, simultaneous viewing of the entire solar surface. Tiny satellites will visit large numbers of comets and asteroids, and when a new object is discovered in the solar system, like the Hyakutake comet, a small satellite can be immediately dispatched to characterize it.

Small satellites, because of their minimal development requirements, will involve a much broader cross section of the science community. With individual program size slashed from billions of dollars to millions or thousands of dollars, the most significant change may be sociological rather than scientific. Nowadays we do one great mission per decade. Assuming only some large program resources are redirected to small missions, there could be hundreds of individual university and industrial science teams pursuing missions at any given time. The probability of breakthrough results and the pace of innovation may well be accelerated by distributing the tools of space exploration into a much larger number of hands.

- Remote Sensing and Earth Environment: There are so many measurements which would benefit humankind, and we currently don't have them since the cost of launching the necessary spacecraft exceeds the budgets for them. A network of small satellites can pinpoint a nascent forest fire and alert authorities within minutes. The fire can be extinguished when it's small enough to be handled by crew of two or three at a cost of a few thousand dollars. Small satellites will map global air circulation to greatly increase weather forecasting accuracy, track pollutants and determine the earth's climatological direction. Real time simultaneous global monitoring can enforce environmental standards and sensitize us to the areas most needy of attention. Rapid assessment of the damage caused by storms, floods, earthquakes and other natural disasters will aid rescue workers in planning and executing relief operations.

- Military applications: Communications via small numbers of large spacecraft is an invitation to disaster in time of war due to antisatellite weaponry. A network of multiple small satellites is much harder, nearly impossible, to defeat. Planetary defense from earth crossing asteroids will require the ability to fly to and inspect, and potentially to interact with these potentially dangerous objects. Small satellites already have the capability to perform this mission. Global surveillance from multiple low orbiting small satellites will provide the intelligence community with hard evidence of production of nuclear, chemical and biological weapons. Some of this new class of satellites have already been developed, and others are being proposed. Denial of access to space utilities, particularly communications and geolocation (GPS) services, can be assured by large numbers of very low cost, very small (1 to 10 pound) satellites orbiting in low earth orbit constellations. Small satellites, and the small, low cost launch vehicles that carry them to orbit, can be launched on demand. Thus we don't need to pay to maintain a huge orbiting infrastructure against unmaterialized potential threats. But when threats are real, small satellites provide the flexibility to immediately build infrastructure on-demand. This force flexibility is key to lowering the cost of space for national defense.

Realizing the promise

The technical impediments to realizing these benefits have been minor compared with the social and infrastructural resistance to small satellites. Too many of the most powerful participants in our national space program have too much invested in the status quo to see it eroded. The small satellite community is by its nature less centralized, and because it is an emergent culture, more marginal. Plus as a society we are familiar with the attributes and deficiencies of conventional space systems - and there is always a risk jumping to the next generation of solutions. What will be its weaknesses?

Looking at the competing technologies as alternative national investments, how do we plan a portfolio, and how do we implement the investing strategy? If small satellites are defined, as I do, as those requiring at most a group of under 20 working within a development period of less than 2 years, (programs with costs including development, launch and operation of around $10M) the US societal annual investment in the technology is currently around $25M - less than 0.1% of our space portfolio. The potential these programs have for the future of space, and their proven utility coupled with their ability to couple space to a much broader segment of our society would indicate that it might be reasonable to shift investment priorities somewhat to favor these small projects in the interest of achieving a more diversified portfolio. A similar increase is already occurring in projects the next size up - say in the $100M class of mission. If small and medium missions were even a 5% portion of the national space budget - $1B or so, we could afford to launch 100 small missions per year and maybe 10 medium sized missions with virtually no impact on the mainstream of space activity. In fact the diversity and complimentary nature of large and small missions would result in a very significant net increase in the effectiveness of our space activities. Government investigation of NASA's centerpiece "Mission to Planet Earth" concluded that breaking huge spacecraft into multiple, smaller platforms, each tailored to a more limited suite of instruments, would improve program effectiveness. Revisiting that study a few years later, the study team regretted only that they had not gone far enough in emphasizing how small the spacecraft used should be and how much of the program should employ smaller satellites.

Defining what is meant by a "small" mission - to ensure money is spent appropriately, is important. the NASA STEDI (Student Explorer Demonstration Initiative) has simply capped the spacecraft cost for development and on orbit operation at $4.3M. But room should be made for projects that might require a number of small, virtually identical spacecraft, and incentives would be desirable for doing even lower cost missions. Our company has proposed all up missions for as low as $300,000 and other commercial vendors have offered spacecraft buses - the satellite without its science or applications payload - for under $500,000.

There are other impediments besides budget dollars small space must overcome. The existence of launch space is critical. Why build a $100,000 spacecraft and pay millions of dollars to launch it? The logic will be that with such a large launch investment, more money should be spent on the payload to increase its utility somehow. While Arianespace of France has aggressively marketed low cost piggyback space, Delta, Atlas and Titan only carry piggybacks when so directed by their US government customer. And when these piggyback slots are made available they are priced so high that no one would actually buy one.

I suggest that each vehicle launched should be required to reserve 5% of its payload for piggybacks flown at minimal cost - at most the cost of the paperwork required to process them. This would provide about adequate launch space for the satellites produced with 5% of the space budget directed to their development and operation. More importantly, it would stimulate commercial interest in space. The true cost of the satellite is low enough, and the existence of reliable transportation to orbit is a key element.

Finally, provision must be made to provide communications links to the satellites. The current system is tailored for large missions of which there are very few. Thus each satellite program completes a lengthy and complex process of application for radio spectrum space for each location it might radiate to or wherever a ground station may reach it from. Compare this to the amateur radio service, which has standing allocations of frequency spectra ready and waiting for exploitation by the amateur community. This has been, over the decades, at least as important as the existence of piggyback launch space to the tremendous success of amateur space programs. Another example are the allocations set aside for Industrial, Scientific and Medical (ISM) applications, which in fact include garage door openers, cordless telephones and a growing family of wireless devices used in the home, at work and on the road. Spread spectrum is simple enough to implement that even the smallest satellites could implement spread spectrum radios to allow largely uncoordinated sharing of spectra.

These three elements - creating a budget wedge for small satellites, allocating launch resource to them, and setting aside shared use radio spectrum space that does not require individual spectrum applications for each spacecraft and each mission - would spawn a renaissance in low-cost, miniature satellites. While I can only postulate the tremendous value these missions would provide to our country, I can guarantee that the experiment would be inexpensive, and would reawaken large segments of our population to the challenges, the excitement and the potential of space.

Conclusion:

Programs like Shuttle and Space Station are justified in part on their appeal to young people. I agree that interesting kids in advanced technology is a special attribute of space. But only small space programs can be built by young people, and built fast enough that a project can go from conception to on-orbit results within the span from sophomore to senior year of high school or college. It is probable that making room in our space investment portfolio for a large number of tiny missions will create more excitement over space, more involvement of our young people in technological possibilities, than our country has seen since Apollo's landing on the moon almost 30 years ago. I believe that this is possibly the only way to maintain the US preeminence in space and to move forward to the next generation of space technology and more importantly of space utility. Those are big goals, but they are real possibilities we can try to unleash with a minimum of cost to the present space budgets.

Chairman SENSENBRENNER. Finally Dr. Ray Morgan, Vice President of Aerovironment.

Dr. Morgan.

STATEMENT OF RAY MORGAN, VICE PRESIDENT, AEROVIRONMENT

Mr. MORGAN. Thank you, Mr. Chairman and Members of the Committee. I am very pleased to be here to talk to you about the possible application of Unmanned Aerial Vehicles or UAVs as they're commonly called for low-cost science missions, such as those required for Mission to Planet Earth.

There are some tasks that only satellites can do, and there are some tasks that only manned aircraft can do, and there are some tasks that UAVs can only and should only do. There is a mix of these three vehicles that will give you the lowest cost science missions of the future.

Aircraft have an inherent advantage somewhat over satellites in doing stratospheric science missions in that they are in situ. They're measuring the environment around them. Also, because there is no space qualification of the payloads required, it's possible to bring fresher, greener payloads to bear that can be developed at lower cost. Also with the manned aircraft you can bring in payloads that are rather heavy cheaply that come straight out of the lab.

Unmanned air vehicles though eliminate the need for the pilot and eliminate about 1,000 to 1,500 pounds that's required to make provisions for a pilot in a stratospheric airplane. Once you've done this you can optimize the airplane around the payload mission. As a general rule on aircraft the lower the weight the lower the cost. The lower mass you fly the lower dollars it takes.

Once you optimize the UAVs around your payload mission and your control system, which are the essential fixed attributes that you can't change, you can achieve a much smaller system, and then you can have higher altitude, longer duration and lower cost than you could have otherwise with manned aircraft.

The early science mission payloads literally came out of the lab and went onto the airplanes, and they weighed thousands of pounds, but now payloads are dramatically dropping in size. For example, the Clementine satellite payload was less than 20 pounds and it flew and took remarkable photographs of the surface of the moon. These types of advances are available for payloads.

In the controls world, and I had it in my pocket, this is the flight control computer that was recently flown on our Pathfinder solar powered airplane. It weighs a few ounces and it has the power of a desk-top computer.

In my other had over here I have a computer the size of a postage stamp that we're experimenting with right now to operate what are called micro-UAVs that ARPA is considering developing for the future of the size of humming birds.

Obviously these are not the complete package. These have to be integrated and therein lies the rub. You have to integrate this into the airplane and package it appropriately. So I would be lying to you if I said this is the size of the electronics boxes on these airplanes, but that is all doable.

Once we have eliminated the need for human factors, we can optimize the aircraft, the UAV around future payloads which are ever going to be smaller, just as my friend here to my left was speaking to. You can imagine working on a desk-top PC that was designed 10 years ago. Nobody would do it.

Aerovironment is currently working under NASA's Environmental Research, Aircraft and Sensor Technology Program to develop a solar-powered airplane, and we believe this solar-powered airplane can provide a stratospheric satellite mission by the New Millennium and it could operate in the stratosphere for months at a time and also provide the ability to pop up to a hundred thousand feet for specific missions.

We made a significant step, and I'm going to flash this picture at the risk of knocking everything off the table in front of me. This is the airplane. It's a little bit unique, but it shows what you can do when you take the pilot out of the airplane. At a hundred-foot span this prototype called the Pathfinder weighed less than 500 pounds, including four science payloads that it carried. Last September we broke into the stratosphere and flew about 50,000 feet. Now that's just a first step. The airplane ultimately will prove out a solar-powered aircraft that can stay up for months at a time and operate 65- to 70 thousand feet and with growth capability up near a hundred thousand feet by the New Millennium.

Also as this airplane will offer extreme duration and extreme reliability due to low-moving parts count, et cetera, the cost per flight hour can approach one hundred to two hundred dollars.

I believe I'm out of time.

Chairman SENSENBRENNER. You have four seconds left.

[Laughter.]

Mr. MORGAN. Thank you.

[The prepared statement of Mr. Morgan follows:]

Unmanned Aerial Vehicles as Low-Cost Science Platforms

by

Ray Morgan, Vice President

AeroVironment, Inc.

April 17, 1996

Thank you, Chairman Sensenbrenner, and ladies and gentlemen of the Space and Aeronautics Subcommittee for the opportunity to talk to you about the potential for advanced Unmanned Aerial Vehicles (UAV's) as low-cost platforms to perform atmospheric science missions. I am extremely proud to play a small part in the effort to help define a public policy in this new, important area. I believe the effort to use the best of our technology to understand how to achieve a desirable and sustainable world is a noble and worthwhile goal, and I and my company, AeroVironment, are eager to respond to this challenge.

UAV's offer the ability to optimize the vehicle around the payload and mission. Such optimization promises higher altitude (at subsonic speeds), longer duration, and lower costs than manned aircraft.

UAV's present a logical complement to missions currently performed by satellites — offering in-situ measurements with smaller, simpler, and cheaper instruments that have shorter development times and lower risks.

Low UAV mission costs, in turn may translate into dramatic cost reductions in future NASA investigations, such as those required for Mission to Planet Earth.

What is a UAV?

A UAV is an aircraft that doesn't have a person sitting on board. They were originally called "Remotely Piloted Vehicles" (RPV); NASA currently prefers the term, "Remotely Piloted Aircraft" (RPA). The true distinction is that no provisions need be made for carrying humans on board the aircraft. To wit....

UAV's have been described as aircraft with no bladder, no brain, no heart, and no fear.

- No bladder means that there are no physiological limits on the duration of flight, and also no provision need be made to accommodate a human on board.
- No brain, in the positive sense, means that the UAV does not get bored. In the negative sense, it means that information must be sent to the aircraft, or carefully stored on board, that allows the vehicle to complete its mission and return safely.
- No heart means that the loss of a UAV has only an economic impact.
- No fear means that the UAV can be sent in harm's way, or to extreme locations without flinching.

These characteristics make UAV's ideally suited to sense atmospheric chemistry and physical characteristics at greater altitudes, duration, and ranges than manned aircraft. It also relaxes lower limits on the size of systems, allowing the development of mission specific aircraft that are inherently smaller, lighter, cheaper than those designed to safely carry a pilot to extreme altitudes and for extreme duration.

Why UAV's?

UAV's can fly cheaper, more up-to-date payloads than satellites

Satellites are much further away from the atmosphere and the earth's surface that they are trying to measure (in fact, 200 to 25,000 miles compared to 0 to 20 miles for aircraft), requiring increased cost and size of the instruments, and sometimes reducing the accuracy of the measurements.

Low and medium earth orbit satellites spend much of their time in the wrong place because of their orbit — they can't continuously survey one site, nor are they easily repositioned.

Satellites, because of the cost of launch and difficulty of repair, often have their technology frozen 5 to 10 years before launch, in order to ensure their reliability. Imagine using a computer that was designed 10 years ago to perform word processing or spreadsheet analysis today!

As an example of the potential rate of technological improvements, I am wearing on my wrist a watch that reads compass heading and measures (and records) barometric pressure and time. This instrumentation is less than one tenth the cost and size of similar instruments available 5 years ago. The UAV offers the opportunity to quickly take advantage of such commercial, off-the-shelf technologies in its payloads, because they can be cheaply recovered — and repaired, modified or replaced — if found to be unsuitable for the mission, thus eliminating the rigorous requirements for "space qualifying" satellite-based payloads.

UAV's can be smaller and cheaper than manned aircraft

To begin, there are a few fundamentals of aircraft design that are worth mentioning:

- The heavier the aircraft, the more it costs to operate.
- The weight of the aircraft is determined first by its "fixed" weights (meaning payload, and avionics), then by its mission, next by its propulsion system, and finally by its structural configuration.

Major General Kenneth Israel of Defense Airborne Reconnaissance Office (DARO) was recently quoted as saying that the total life cycle cost for the SR-71 was $38,000 per flight hour, for the U-2 was $6,000 per flight hour, and for historical (military) UAV's was $2,000 per flight hour. Technologies are maturing in current NASA programs that could reduce the life cycle cost of UAV's by another factor of 5 to 10.

A comment often made in the information technology field sets the stage..... Electronic engineers note that if cars had been developed over the last two decades as effectively as the technology and economy of data bytes, the modern Cadillac would now sell for about one dollar. Unfortunately it would also be the size of a walnut.

However, there is a message applicable to this discussion..... In high-altitude, pressurized jet aircraft, provisions for a human pilot can easily add 1000 pounds to the weight of the aircraft, in addition to the pilot. But, once the pilot is removed, the scale of the UAV can be reduced as the other "fixed systems" weights are reduced.

Early science missions were taking instruments from the laboratory and putting them on aircraft and in space. These payloads sometimes weighed thousands of pounds. But, the trend of miniaturization in electronics promises a dramatic reduction in such instruments in just a few years. As stated above, reducing the weight of the payload and the control system reduces the weight of the aircraft. Reducing the weight of the aircraft will invariably reduce the cost of operation.

What about the avionics systems? I have in my shirt pocket one of the computers used to fly our solar powered UAV, the Pathfinder. I am holding in my (other) hand a computer the size of a postage stamp, that we are experimenting with for "Micro-UAV's" for the future. These electronic devices are indicative of the possible reductions in the other half of the "fixed" system weights, that will dictate the total weight of the UAV.

This is a trend that must be recognized and capitalized on: By the end of this decade, payloads and control systems will be so small, that carrying a human pilot would be like putting an elephant on a bicycle! The UAV's being developed to perform these missions should be optimized for the smaller payloads of the future, in order to achieve a balanced design, and thereby minimize the cost of getting science data from the stratosphere.

UAV's can fly higher, further, and longer than manned aircraft.

The highest-flying, manned, subsonic aircraft today, the ER-2 (a variant of the U-2), is limited to a little over 70,000 feet in altitude. The SR-71 can fly much higher, but must fly several times the speed of sound to keep its engines running and maintain lift in the rarefied air, making it unsuitable for most science measurements of the atmosphere.

The flight duration of an ER-2 and SR-71 is limited because of the stress of flying in the space suits required for very high altitudes. Even with in-flight refueling, a 10 hour mission is a grueling ordeal for any pilot.

In contrast, a UAV is uniquely capable of being tailored with few limits to meet the mission requirements. Omission of human factors constraints opens the design options dramatically. Missions approaching altitudes of 100,000 feet, or of month-long duration and ranges that are global, could be available by the new millennium, using technologies already identified.

Recent developments in the field of electronics, navigation aids (like the Global Positioning System — GPS), and other supporting technologies permit dramatic improvements in the function of robotic aircraft, that can make a substantial impact on the cost and effectiveness of scientific research missions in our atmosphere. Over the last three years the DoD, the DoE, and NASA have determined that robotic technology, miniaturization, and computers have reached a stage of maturity that UAV's should be aggressively pursued. Technology improvements were not the only drivers, for unremitting budget pressures have also driven the sponsors to consider cheaper alternatives.

What is being done now?

My company, AeroVironment is currently working with NASA under the Environmental Research Aircraft and Sensor Technology (ERAST) program to develop a solar-powered UAV. This unique aircraft, only possible if unmanned, should be able to offer the function of a true, "atmospheric satellite" operating in the stratosphere, around the world (mid-latitudes, to poles in summer), by the end of this decade. Variants of this plane can also offer the possibility of "popping up" to 100,000 feet for specific missions. Significant progress on the path to this eventual capability was realized on 11 September 1995, when the first testbed for the solar-powered UAV, called "Pathfinder" (shown on the cover of this document and appended herein), weighing 500 lbs., achieved a world altitude record for electric aircraft of 50,500 feet at NASA's Dryden Flight Research Center in California, carrying four light-weight payloads.

The NASA ERAST program was established to allow industry, government and academia to work together to mature UAV technology to support science needs as quickly and productively as possible. To this end, the ERAST program has been an immense success in allowing government and industry *competitors* to work cohesively together as a team with challenging goals to meet. NASA has wisely initiated this program by leveraging technologies from prior government activities to fly science missions.

We at AeroVironment are honored to be a part of the ERAST alliance, that includes three other developers of UAV's. Several approaches to unique propulsion systems, aircraft control systems, and configurations are being tested and evaluated in parallel to determine the most promising solutions for the science missions. All alliance members are developing technologies, performing test flights, and gathering and sharing data to enhance the probability of meeting the ERAST goals. Multiple flights with science payloads by ERAST UAV's have already been made into the troposphere, and stratosphere. Lessons learned in propulsion, controls, structures, aerodynamics, payload integration, and flight operations will be applied to the design of the vehicles optimized for the science payloads and missions later this decade. We believe that one of the internal combustion engine systems being evaluated will provide the logical complement to the mission capabilities of the solar plane.

What is even more encouraging is that scientific payloads are also undergoing a revolution in size and weight reduction akin to the Clementine satellite that mapped the moon and whose payload weighed in at a mere 15 pounds. Small, high performance payloads, in turn, reduce the size, cost, and complexity of the aircraft platforms.

What lies ahead?

The results of these tests and numerous studies lead us to the conclusion that low-cost, high-altitude, long-endurance flight is on the horizon. However, developing the UAV's to a level of maturity similar to that of current manned aircraft is critical to obtaining low cost missions.

Solar-electric aircraft will be capable of significant mission capability of astounding range and duration as time unfolds. Proven reliability, coupled with advances in communications, such as NASA's TDRSS (data relay satellite system), will permit a remotely piloted aircraft, such as the solar plane described above, to launch from the continental US, operate autonomously for months at a time at various locations around the world, and then recover on command to its origin. Such reliability and extreme flight duration will lower life-cycle-costs to a few hundred dollars per flight hour in a mature system.

The UAV is not a replacement for the other approaches to science data gathering, but a complement. There are tasks that only satellites can perform. There are tasks that only manned aircraft can perform. But there are also tasks that only UAV's can perform. The era of the UAV is upon us — there will be no looking back. The United States is in a leadership position to exploit this capability — it should not be relinquished. In this vein, we would not be where we are today without the help of our NASA sponsor that created the proper environment to stimulate creativity for us to “push the envelope”. The NASA ERAST program is the *only* government sponsored program that is specifically addressing the development of UAV's suitable for science missions between 60,000 and 100,000 feet, and needs to be continued vigorously and robustly.

We are committed to apply advanced technology to lower the cost of scientific observations. Remotely piloted aircraft acting as true, "atmospheric satellites" are about to become a reality. We are honored to be a part of this effort.

Again, let me thank you for the opportunity to present my opinions on UAV technology and how it could significantly enhance NASA's mission — specifically Mission To Planet Earth. Your support in providing stable funding in the out-years will vastly improve our chances of achieving “virtual eternal” flight by the new millennium.

Company Background

The record flight of the Pathfinder solar-powered UAV is the culmination of over 15 years of solar-electric research conducted by AeroVironment, Inc., head-quartered in Monrovia, California. AeroVironment was founded by Chairman Dr. Paul MacCready in 1971 as an environmental and meteorological research company. Since then, our mission has evolved to “helping provide a desirable, sustainable world through the use of technology”.

Dr. MacCready first used unpiloted aircraft dropped from balloons to perform science missions in the early 60’s. We began developing manned solar powered aircraft in 1980, as a showcase for using modern composite materials to improve efficiencies and for the potential of photovoltaic conversion of sunlight as a renewable energy source.

We have been in the business of developing light-weight, highly-efficient air, water and ground vehicles for government and commercial customers since that time, while continuing our core business of environmental research. Five of these vehicles have been acquired by the Smithsonian Institute to represent unique approaches of the limits of technology. One of our electric-powered, reconnaissance RPA’s, the POINTER, produced for the RPA Joint Project Office, resulted in our being awarded the Total Quality Management flag by the Naval Air Systems Command.

The underlying theme of these extremely efficient systems has been “doing more with much less”.

Pathfinder History

In the early 1980’s, after successfully flying the Solar Challenger, solar-powered, manned aircraft from Paris, France to Kent, England, we began work on studying the feasibility of an unpiloted, solar-powered aircraft that could stay aloft on solar energy for months at a time. We were fortunate to interest a government agency in sponsoring an unpiloted aerial vehicle that would operate solely from the sun’s energy, that could provide extremely long duration.

This aircraft, then called HALSOL, would use photovoltaic cells on the top of the wing to convert sunlight to electricity. Part of the power would go to the eight electric motors and payload directly, and part would be stored on board to operate the motors and payload during the night. The small amount of power available from the sun demanded that this aircraft represent the ultimate in light weight and aerodynamic efficiency. The extremely long duration of flights, expected to be on the order of thousands of hours, also required that this aircraft be perhaps the most reliable aircraft ever flown in the earth's atmosphere. An interesting aspect of the need for reliability and light weight, is that this need results in a system with a low operational cost.

In order to achieve this low weight, efficiency, and high reliability, a unique, multi-engine, span-loaded, flying wing design was selected. The unusual configuration of this aircraft presented challenges in aerodynamics, structures, controls, and propulsion. To prove out this unique configuration, a series of five, progressively larger scale models were built, each one including more of the planned propulsion and control systems. The fifth proof-of-concept vehicle, POC-V, was one hundred feet in span and had eight motors and propellers distributed along the wing. The motors were used for lateral control as well as propulsion. The POC-V completed a series of nine flights in the summer of 1983, proving the viability of its configuration, although the reliability of its motors and avionics were not yet sufficiently developed.

This aircraft was carried through the original flight test period, after which a study of available energy storage systems was made, and an analytical model for mission analysis constructed. Results of this study indicated the available technologies for energy storage lacked sufficient storage capacity per pound to perform the needed mission, and the POC-V HALSOL vehicle was placed in storage.

In 1992, the Ballistic Missile Defense Organization (BMDO) became interested in airborne platforms that could perform as "sentinels" to continuously monitor a potential SCUD missile launch site, and provide Boost Phase Intercept capability using small, kinetic weapons carried on board. AeroVironment was under subcontract with Lawrence Livermore National Laboratory (LLNL) to provide an evaluation of potential concepts to provide the platform for the launch detection system and kinetic weapon, named "RAPTOR TALON". Our preliminary survey showed that current technologies for fuel cells offered sufficient energy storage per pound to make the mission feasible using solar power. This concept appeared desirable for further test and evaluation by BMDO for this mission because of the extreme duration and range it offered. At this time, the previous HALSOL POC-V vehicle was declassified, removed from storage by the previous government sponsor, and transferred to this effort at our recommendation, for refurbishment and continuation of the test program. NASA's Dryden Flight Research

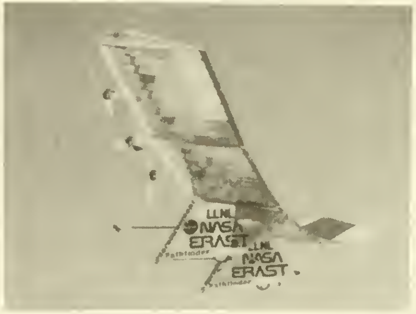
Center was interested in the concept as it might be applied to science missions, because of the potential performance, low-cost, and non-polluting nature of the propulsion system. Dryden offered a test facility for the program, which was ideally suited to the solar plane. In 1994, programmatic reductions forced BMDO to abandon the study, although not until after a series of successful low-altitude test flights had been made of a refurbished HALSOL, now dubbed RAPTOR Pathfinder by BMDO. Further information on the Solar plane and its development plans are included in an excerpt from a "Popular Science" magazine appended herein. Also see further programmatic summary information in charts appended herein.

We were fortunate to have been invited to join the alliance of UAV developers that formed the nucleus of the ERAST program to continue development of the solar-electric concept for environmental missions. Other UAV developers/manufacturers in the ERAST program are Aurora Flight Sciences, Manassas, VA, General Atomics, San Diego, CA, and Scaled Composites, Mojave, CA.

Appendix

NASA ERAST - Solar Electric UAV

Pathfinder



World Record: 50,500 feet on 11 Sept 1995

Capabilities

- High Altitude (20-30 Km)
- Long Endurance (Days-Months) for Polar Summer Missions
- Small Payloads (<40 kg)
- Very Stable Platform
- Very Slow Flight
- Environmentally clean — all electric
- Upgrades to Surrogate Satellite (Helios) with incorporation of Energy Storage System

Missions

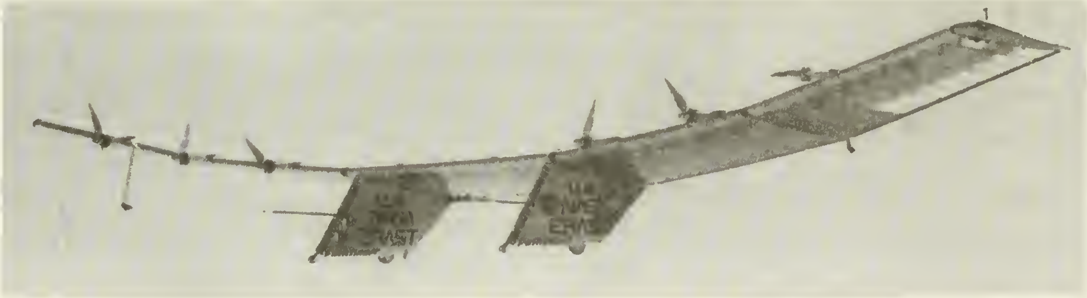
- Remote Sensing
  - Early Data Collection for Mission To Planet Earth
    - Polar Laser Altimetry/Radiometry
    - Large Scale Turbulence/Subsidence
    - Atmospheric Monitoring (Particulates /Effluents)
    - Radiation Monitoring
- Aeronautic Data Collection
  - Aircraft Flight Performance
  - Airfoil Characterization
  - Sensor Testbed
- Telecommunications Relay

Advantages

- Early Scientific Data Collection
- Risk Reduction for Satellite Sensors
- Good Public Relations for NASA by Using Innovative, Low Cost Solutions
- Leverages >$6M Invested by DOD
- Low Risk, Potential High Payoff at Low Cost
- Keeps Concept on Path Toward Virtually Eternal Airplane for America
- Energy storage developments have application to space and terrestrial systems

NASA ERAST - Solar Electric UAV

Pathfinder



Goals

- 65K ft at Edwards, Fall 1996
- Hawaii Science Mission, Spring 1997
- Design and Fab of Helios POC I , Summer 1997
- Energy Storage System Validation, 1997
- Flight Tests of Helios POC I, Fall 1997
- Design and Fab of Helios POC II, 1998
- Fab of Energy Storage System, 1998
- Flight Tests of Helios POC II, 1998
- Design and Fab of Helios POC III, 1999
- Flight Tests of Helios POC III, Day & Night, 1999

Issues

- Solar Array and Flight Test Funding Uncertain, $3M needed in 1996
- $10M required in 1997
- $20M required in 1998
- $16M required in 1999

Ultimate Goal:

US/NASA to demonstrate high-altitude "virtually eternal" flight by the New Millennium (31 Dec 1999)

AVIATION WEEK
& SPACE TECHNOLOGY
JANUARY 29, 1996
1995
Laurel
Awards
Aviation Week Group
McGraw Hill

AEROSPACE 95 LAUREATES

AVIATION WEEK & SPACE TECHNOLOGY presents its 39th annual Aerospace Laurels selections, honoring individuals and teams who made substantial contributions to the global field of aerospace in 1995. Honorees were selected from nominations by Aviation Week editors in Commercial Air Transport, Operations, Electronics, Space, Aeronautics/Propulsion and Government/Military. Following the inauguration of a Lifetime Achievement Award last year, an honoree in this seventh category also has been named for 1995. The persons, or teams, who made the outstanding contributions in the categories are the Laureates for 1995. Articles on each Laureate appear on pp. 15-19, followed by the honor roll of individuals who have earned Laurels citations, on pp. 20-22. Each Laureate winner will receive the Laurels Trophy at ceremonies in Washington during April.

AERONAUTICS/ PROPULSION

Ray Morgan and Bob Curtin for the AeroVironment Pathfinder drone

The dream of perpetual flight came measurably closer last September when the AeroVironment solar-powered Pathfinder drone reached 50,500 ft. Solar-powered flight was almost laughable in 1970. Dedicated work by several groups since then has turned it into a reality that is just a hair away from practical use.

Pathfinder is the product of teamwork, but two individuals stand out as driving forces in the program's success. They are Ray Morgan, an AeroVironment vice president, and Bob Curtin, the company's Pathfinder project manager.

Morgan left Lockheed's Skunk Works in 1980 to build AeroVironment's early solar-powered efforts, which started as a collaboration between AeroVironment President Paul MacReady and Bob Boucher of Astro Flight. Morgan led conversion of the human-powered Gossomer Penguin into a manned solar testbed, and then designed and built the Solar Challenger that crossed the English Channel in 1981.

Morgan took on the solar project because of his interest in building a practical aircraft powered by a nonpolluting, renewable energy source. "I consider this to be a career objective," he said.

The Channel crossing heightened the interest of a government agency, which funded AeroVironment's high-altitude solar (Halsol) project. This is the aircraft that 10 years later became the Pathfinder. Morgan was the chief engineer for Halsol and ran the division under which it was produced. His insight on aerodynamic reality, flight test skill and cautious approach to a daring goal were crucial to the program.

The 100-ft.-span Halsol was the prototype for a 200-ft. perpetual flyer that was to stay above weather and winds for months at a time. After further study and 9 hr. of flight test, officials concluded that the energy storage for the desired nighttime flight was not yet feasible.

Ray Morgan has pursued making a nonpolluting aircraft into a practical reality.

Bob Curtin led the effort to take the solar-powered Pathfinder to 50,500 ft.

Halsol emerged from storage in 1992, renamed Raptor Pathfinder and funded by the Ballistic Missile Defense Organization and the Lawrence Livermore National Laboratory. This funding dissolved before reaching high altitude, but the altitude goal was kept when the project was transferred to NASA's Environmental Research Aircraft and Sensor Technology program in early 1995.

Halsol's 1980s technology had enough climb rate to theoretically reach 50,000 ft., but one important piece was missing—the reliability to do so. This final component was added with major system rework under Pathfinder. Morgan continued in an oversight role with Pathfinder while Curtin took the reins as program manager.

Curtin had helped build and test Halsol as a teenage worker on the classified project. He continued at AeroVironment, earning an M.S. in physics along the way. Curtin led the front lines in pushing Pathfinder from being a curiosity of unrealized potential into a nearly practical high-performance aircraft.

Pathfinder will set more records this summer if the federal budget and new solar cells are in place. The next project will be "Helios" to stay aloft for several summer months. Morgan believes Helios could be a reality before 2000, to do some of the jobs that aircraft and satellites now do. ■

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Popular Science
ETERNAL Airplane
A solar electric wing takes off

The ETERNAL AIRPLANE

BY STUART F. BROWN

The liftoff of unman [illegible]

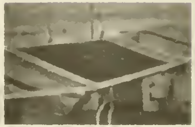
Men with streaming telltales on long poles monitor breezes while the dawn sky shifts from reddish to pale gold. History is being made, and it sounds like a whirring window fan. Make that a chorus of window fans.

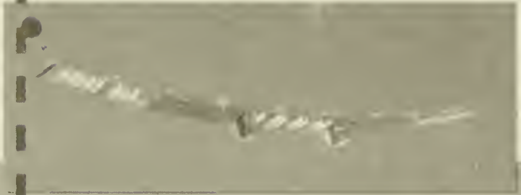
As its eight propellers begin to spin, the drooping tips of an immense, spindly wing rise almost immediately. Rolling on a pair of wheeled pods across the dry lake bed at Edwards Air Force Base, Calif., the wing continues to bow upward. Its eyebrow-like curvature evolves into a Mona Lisa smile as the solar-electric Pathfinder leaves the ground. The takeoff roll is just 80 feet—less than the craft's own wingspan. It climbs to an altitude of 200 feet, sunlight glinting from the clear plastic wing skin. Flight speed is a bicyclist's 15 mph. Barely a sound can be heard.

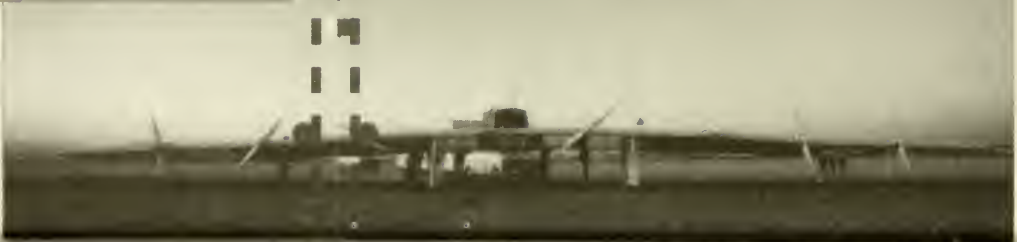
This airplane has remarkable potential. If it lives up to expectations, an advanced version could fly around the world in about 80 days at an airspeed averaging 90 mph. On a longer weather reconnaissance mission, it could take off from California in April, traverse Australia, then pass over the Middle East. Sailing eastward, it could follow a hurricane's progress from West Africa to the Caribbean, finally returning to a West Coast airfield for a late-June touchdown. It could also perform military missions, monitoring troop movements for weeks while pinpointing Scud-type missiles as they ascend. And fitted with communications equipment, it could work as a mobile relay.

Flying a 2,000-to-3,000-hour mission would require the sun-powered craft to be the most reliable airplane ever built. An incidental reward would be shattering the world endurance record for powered flight.

Viewed from above, the Pathfinder looks like a [illegible]

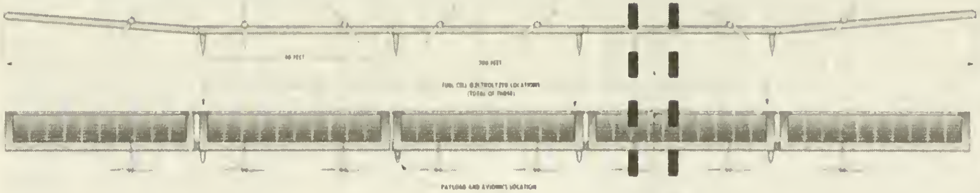


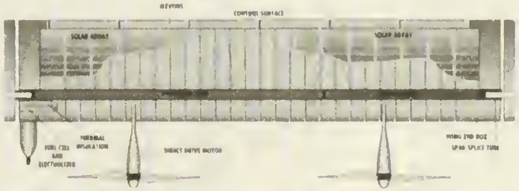


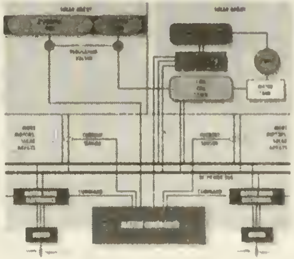


Each propulsion unit (top) weighs just 13 pounds and consists of a fixed-pitch propeller, motor with internal power electronics, nacelle, cooling fans, and mounting strut. The solid-state 1.5 horsepower motors are derived from the AeroVironment design developed for the General Motors Impact electric-car prototype. At the remote-control pilot's station on a chilly morning (second from top), designer Ray Morgan prepares for takeoff. Segmented solar arrays (above left) follow the contours of the 100-foot wing's upper surface, which is only partly "populated" with silicon photovoltaic cells in this photo. In flight (far right), the airplane flexes into the upward bowed dihedral angle that gives it roll stability. Space shuttle Mission 58 (above) was undergoing postflight processing when Pathfinder flew by last October. On the ground (bottom right), pylons under the outboard tips prevent overstretching of the transparent Mylar wing skin.

200-FOOT HELIOS: THE NEXT SOLAR ELECTRIC WING


40 FEET
200 FEET
FUEL CELL ELECTROLYZER LOCATIONS (TOTAL OF THREE)
PAYLOAD AND AVIONICS LOCATION





The planned successor to the Pathfinder is called Helios. Its 200-foot span (top) is comprised of five modular, 40-foot sections, supported by a quartet of landing pods. Eight electric motor-propeller units similar to Pathfinder's provide propulsion. A tubular carbon and aramid-fiber wing spar running across the span is the main structural element. Proton-exchange membrane fuel cells located above three of the landing pods serve as storage batteries. During sunlight hours, surplus current from the solar array electrolyzes water into hydrogen and oxygen gases, which are compressed and stored inside the wing spar. At night, the fuel cells provide electricity for the engines by recombining the gases. The sole by-product—water—is stored, and the closed-loop cycle repeats daily (see diagram at left). The Helios will carry its avionics system and 150-pound payload above one of the inboard landing pods.

[illegible] batteries [illegible] compared.

[illegible]

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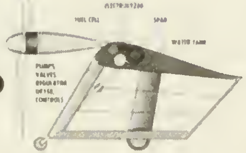


need to package it into a lightweight system, which will take about two years of engineering. But no fundamental breakthrough is needed in the chemistry or the materials."

The airframe now called Pathfinder has a [illegible] past. It first flew in 1983 under the name HALSOL (high altitude solar energy) as part of a classified program sponsored by an unnamed agency to explore the feasibility of long-duration solar electric flight in the thin air at altitudes above 65,000 feet. HALSOL flew nine times in two months, eventually reaching an altitude of [illegible],000 feet powered by rechargeable silver zinc batteries.

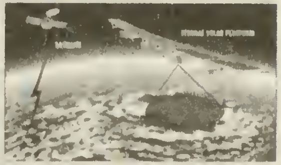
Sources outside the program have revealed that testing [illegible] at the unacknowledged [illegible] at Groom Lake, Nevada. Organizations known to have studied [illegible] powered aircraft include the Air Force, the Naval Research Laboratory, [illegible] National Reconnaissance Office, and NASA. Which one was the customer? That's a secret.

The craft proved [illegible] with the [illegible] and power [illegible] equipment [illegible] SOL embodied ideas that were ahead of the state of technology [illegible] and it was parked in long-term storage.

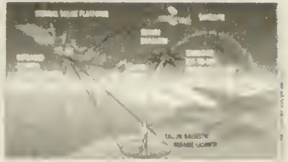
The rebirth of HALSOL as the Pathfinder [illegible]

JOBS FOR LONG-DURATION HIGH FLYERS

An eternal airplane could function as an atmospheric "pseudo-satellite," providing a relocatable over-the-horizon communications relay or a persistent platform for reconnaissance sensors. In military use, the craft would fly a racetrack-shaped pattern above friendly territory and peer into areas of conflict. Civil roles might include border patrol and disaster management during forest fires or earthquakes, when local telecommunications are interrupted.



Severe storm tracking at altitudes of 60,000 to 80,000 feet is a likely role for an eternal airplane. Flying above a hurricane's fury, the drone could monitor the storm's evolution and course, warning of an impending landfall. Because it is electrically powered and breathes no air, the plane could safely fly atmospheric sampling missions through abrasive volcanic ash or the radiation released in a nuclear powerplant accident.



The Ballistic Missile Defense Organization is exploring solar drones as platforms for detecting launches of Scud-type ballistic missiles, then attacking them during the boost phase of their flight, when the [illegible] plume is easily detectable by infrared sensors. A 50-pound [illegible] could be launched from the drone [illegible] the missile [illegible] collapse.

flight a decade ago can do it today.

New motors, power-control electronics, flight-control actuators, autopilots, and lightweight, high-performance silicon solar arrays make the difference. Now, when electrical losses and mechanical friction in the propulsion system are considered, seven percent of the solar energy collected is converted into propulsive thrust powering the airplane, Colella says. The best system that could be built in 1980 was only four percent efficient. The new motors need no gearboxes, and fixed-pitch propellers replace the complex variable-pitch props previously used, eliminating almost 100 parts from each motor pod.

A lot of things happen to a solar-electric airplane as it gradually climbs from a runway in the dense air near sea level to the cold, thin air at very high altitudes. On takeoff, Pathfinder's props spin at about 300 rpm to reach a lazy 15 mph. As the craft ascends through the thinning air, motor speed must increase to maintain the propellers' thrust, and airspeed must increase to maintain the wing's lift.

At 70,000 feet, the motors need to spin at 1,700 rpm to reach an airspeed of about 90 mph. Cruising in the middle stratosphere requires about six times the power and speed needed at sea level. Fortunately, the solar cells increase their output somewhat during the climb, due to better cooling and escaping the atmospheric haze present at lower altitudes.

Ascending through the powerful and unpredictable winds of the jetstreams will be the airplane's most formidable trial. Consequently, it's built to withstand five-g loads during flight. The effects of strong gusts are minimized by distributing the wind's force throughout the featherweight airframe.

Though Pathfinder lacks the fuel cell energy-storage system slated to appear in its successor, the Helios, the craft actually could fly for weeks on end—as long as it's in the vicinity of the North or South Pole. If funding permits, the airplane may be launched from Allen Army Airfield near Fairbanks, Alaska, during the summer months when continuous daylight above the Arctic circle would provide 24-hour solar electricity. New bi-facial solar cells to be installed on the transparent wingskins will make the most of the low sun angles encountered in polar regions by capturing some of the energy of the earth's albedo, or light reflected upward from the clouds and atmosphere below.

Before departing on such an exotic mission, Pathfinder must first pass high-altitude flight trials. This spring, the craft is slated to climb to 60,000 feet or higher. Taking off at seven a.m., the solar flyer should be able to reach a 60,000-foot altitude by about 2 p.m. Many miles from the radio-control van that follows the plane at takeoff, the drone needs to switch over to an autopilot system that will control its flight.

The autopilot's basic software was developed during last year's series of flights up to a maximum altitude of about 200 feet. Ray Morgan sat in his command chair atop the chase van, calling off endless lists of flight-control settings that pushed the Pathfinder to the edges of its safe flight envelope—and a little beyond.

During a right turn, for example, the outboard-most propeller at the left wingtip was run at a high-power setting, while its counterpart at the right wingtip slowed to a standstill. Stall speeds and instabilities were noted, and the best combinations of motor speed and elevator positions determined. The results are encapsulated in a software program that makes the plane capable of autonomous flight using small computers, compact gyroscopes, and four-antenna global positioning satellite (GPS) equipment that senses the craft's pitch and yaw and roll angles, as well as its location.

Pathfinder is funded by the Pentagon's Ballistic Missile Defense Organization (BMDO) under the code name Raptor Talon, which symbolizes a bird of prey with fearsome claws. The Talon part of the program involves developing a small, high-velocity rocket that could be stored in pairs aboard Pathfinder derivatives, giving them the ability to attack hostile missiles in flight.

BMDO wants to be able to destroy high-explosive, chemical, or biological clustered-submunitions in flight, before they can separate from a missile's warhead and inflict damage on the ground. "I look at these Raptors as very visible targets flying border patrol over the enemy, keeping him on his toes 24 hours a day," says program manager Lt. Col. Dale Tietz. "We're going to try to have the Talon be so precise that it knows what target it's after, where the warhead compartment is, where to hit it—and from what angle—to really wipe out the weapons."

Experience gained from Pathfinder and the proposed 200-foot-span Helios could lead to the development of commercially available solar-electric drones. Program officials estimate they would cost $2 million to $3 million apiece, assuming a minimum production run of 20 aircraft. Sometimes supply can create demand. Who knows what unforeseen uses may be found for eternal airplanes?

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Chairman SENSENBRENNER. The gentleman from Florida, Dr. Weldon.

Mr. WELDON. Mr. Morgan, your airplane is fascinating, and I'm just curious. How can you stay up after dark with a solar-powered airplane? Are you going to just travel always in the path where the sun is? Is that what you're talking about?

Mr. MORGAN. That's a very good question, and that actually is the key technology that we hope to develop in the next few years. The technology of today is adequate to provide an energy storage system that would allow us to store energy, excess energy recovered from the sun during the day and operate overnight. This would allow you to stay up literally months at a time. You're limited by things like bearing wear life and gear life of the systems.

That system has not been engineered to operate in this airplane due to funding constraints, but as we go forward with NASA ERAST program we hope that that will become available, and there are other drivers pushing this technology, too, because energy storage is key to things like electric-power vehicles which our company is also involved in. You may have heard of the Sun Racer or the General Motors impact electric car which is now available as the EV-1. We were involved with those development programs.

Mr. WELDON. Just a follow up curiosity question. You talk about getting the very high altitudes, 100,000 feet. I thought you needed speed to get the lift to get you up to those altitudes, but your prototype is a prop plane?

Mr. MORGAN. That's correct.

Mr. WELDON. How are you going to do that?

Mr. MORGAN. Well the reason is that the airplane is extremely light weight. The weight of this airplane per unit area is about equal to the foam core which is backing this picture right here. There is about an eighth of a pound per square foot, and if you're very, very light weight then you can still get enough lift and not go supersonic. The problem with manned aircraft is you run into a corner where you really need to start flying at supersonic speeds to go to the very high altitudes, which is why the SR-71 can fly higher than an ER-2.

But with the extreme light weight and the large size, which also goes hand in hand with solar power collection because we only get about 10 watts a square foot, then you can start to achieve these. I'm not guaranteeing a hundred thousand feet, but it shows analytically that the approaching of those extreme altitudes, it's only possible subsonically with these types of aircraft.

Mr. WELDON. I have just a few questions for Rick Fleeter, Dr. Fleeter. We had earlier in the year some testimony from the Department of Energy that using distributed systems and advanced remote sensing that some of the components of the Mission to Planet Earth Program could be done at substantially increased cost savings to NASA. I wonder if you are familiar with that at all or if you can comment on that?

Mr. FLEETER. I'm not the expert on that subject, but I get asked questions about the efficiency of building small satellites for those missions, and there are a number of them.

One of the easiest ones to see is that different instruments want to do different things. They want to look in different directions.

They want to scan the earth one way or they want to stare directly down from the satellite. That's very hard to do when everybody has to live together on one bit platform. Whereas if you break the platforms up and you say well this one is going to do nothing but stare straight down, this one is going to be looking at the limb of the earth so that we can look at the atmosphere better, and another one is going to be in a scanning mode where it maps out the earth's surface, that's much easier to do on three different satellites than it is to do on one satellite. That's one of the efficiencies that you get when you break things down.

Mr. WELDON. Do you think the industry as it exists today could support restructuring the program in that way and that the capabilities are out there to realize cost savings like that?

Mr. FLEETER. I do think that it is, and the reason that I think so is that our company is maybe a very small part of that whole society and we build satellites that are the very smallest, and not all of these missions that you're talking about would be appropriate for someone like us. The larger companies have gotten into these so-called small satellites, what I would call medium-sized satellites, and almost every one of the major contractors and several smaller companies like ours are, you know, interested in that and that's the thrust of ours.

But the other comment that I would make about that is that we have an idea of satellites, but because they're very large they take special facilities, and only a few places in the world have those facilities to build very large satellites. Small satellites can be built in a lot of places and so without that constraint of needing to focus on two or three places you can really get a lot done.

Chairman SENSENBRENNER. The gentleman's time has expired.

The gentleman from Texas, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman.

I'll go to Colonel Payton, and for the exhibits that you brought would you direct your attention to the first one there. Those are I guess what we would call tiles?

Colonel PAYTON. Yes, sir, that's right.

Mr. HALL. And they are on the front of the bird and the underbelly of the bird where there is the most friction and heat?

Colonel PAYTON. Yes, sir, that's right.

Mr. HALL. About how many of those are on a shuttle?

Colonel PAYTON. The number of tiles on each shuttle is a little bit different depending on the number of blankets that are on the bird, but it's measured in the thousands.

Mr. HALL. Like about how many thousands, have you got any idea?

Colonel PAYTON. I'll gladly answer that for the record, but for the black tiles it's probably five or six thousand.

[The following information was received for the record:]

The three newest orbiters (Atlantis, Discovery and Endeavour) each have 22,813 black tiles and 518 white tiles. The oldest orbiter, Columbia, has 23,246 black tiles and 3,208 white tiles. The newer orbiters have fewer tiles due to more extensive use of Thermal Protection System (TPS) blankets.

Mr. HALL. Now for one of those tiles there, who are the contractors on that? Who do we buy those from, Rockwell or Lockheed?

Colonel PAYTON. I honestly don't know.

[Colleague confers with Colonel Payton.]

I understand that it is Rockwell that is delivering the current suite of tiles, and it has been a cooperation between Rockwell and Ames Research Center that has developed these new generations of ceramic tiles.

Mr. HALL. All right. Is that the newest tile, and what happened to titanium? I think you started out with that.

Colonel PAYTON. Yes, sir. That's over here. That's the metallic tile.

Mr. HALL. Is that on the rest of the bird?

Colonel PAYTON. Not today's orbiter, but one of the designs that we have for the X-33 would have this sort of thermal protection system on it.

Mr. HALL. You know, we're in a cost-cutting situation and trying to do more with less. Do you have any idea what one of those five-by-six tiles costs the government?

Colonel PAYTON. No, sir, I don't, but I can dig that out and supply it for the record.

[The following information was received for the record:]

Ceramic thermal protection tiles currently cost between $500 and $1,000 per square foot to purchase. The difference is largely due to production rate, the upper and lower limits are representative of the Space Shuttle and the B-2, respectively. Installed on the Space Shuttle, tiles cost about $10,000 per square foot; current estimates are that for a next generation reusable launch vehicle, installed cost of advanced tiles will be about $2,000 per square foot.

Mr. HALL. Do you have any idea?

Colonel PAYTON. No, sir.

Mr. HALL. Are they all different on the tiles?

Colonel PAYTON. On today's orbiter the tiles have a unique, if you would, tail number or part number. One of the intents of the X-33 program is to make each individual tile larger, and again whether it's ceramic or metallic, each one could be larger and there could be more commonality amongst different tiles.

Mr. HALL. What is the engineering effect? They were about four by four, and now that appears to be six by six or five and a half by five and a half.

Colonel PAYTON. Especially for a metallic one if you can make it larger, each tile larger, you have fewer attachment posts, and attachment posts end up being a pretty large weight factor.

Mr. HALL. When we're talking about cutting costs would it surprise you if those initial little four-by-fours cost as much as $500 each?

Colonel PAYTON. I honestly don't know, sir.

Mr. HALL. Would it surprise you if they cost a thousand dollars each?

Colonel PAYTON. I'm not qualified to talk about the price of an individual tile.

Mr. HALL. Probably I should have asked the downsizer, Professor Kay about that when he was here, and I'll get with him and ask him later. Those are things I would like to know, and I think the Committee would like to know. I know what they cost initially, and I would like to know what they cost today.

Colonel PAYTON. What we're trying to do and what we, and through these sorts of demonstrations what we will show is that when you manufacture the set of tiles, again whether it's ceramic or metallic, when you manufacture that set of tiles with the newest technology you don't have to spend the manpower to inspect them, and you don't have to build new ones as often.

Mr. HALL. But the facts are you have to remove some of those or improve them after each flight?

Colonel PAYTON. No, sir.

Mr. HALL. You do not?

Colonel PAYTON. That's what we're trying to show with these sorts of demonstrations.

Mr. HALL. And then if those are more than $1,000 each, you're going to use fewer of them and that will be something you'll crank into the computer.

Colonel PAYTON. And each one lasts longer during the life of a bird.

Mr. HALL. Colonel, I thank you.

I yield back my time.

Chairman SENSENBRENNER. The gentleman from California, Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman.

I was just listening there to what Mr. Fleeter had to say about this Mission to Planet Earth and the huge satellites compared to smaller satellites, and it seems to me that the Edsel syndrome is still at sway here. If you remember the Edsel back in the 1950's, Ford thought they were going to build a car that basically did everything for everybody, and by the time they got the car built nobody liked it at all. It was a car that was built for nobody because it was built for everybody, and I guess you're saying that we should be specializing in smaller satellites that can do a specific job rather than trying to do everything for everybody.

Mr. FLEETER. Definitely for a lot of reasons, one of them being that even in Mission to Planet Earth by the time you get all the constituencies together and finally agree on a platform a lot of times that problem is not really the problem any more. A lot of these programs go on and go to flight, and one of the frustrations of a lot of satellite builders is we work very hard to build these things and by the time they get into orbit really nobody cares too much about them any more.

Mr. ROHRABACHER. Well that's a very good point. So you're saying that by the time everybody agrees about half of the projects that are going to be on the platform are obsolete anyway. That's very well said and I appreciate your testimony.

Colonel Payton, I would like to ask you a little bit about the X-33 program. As you know, I have a special interest in the program, and I would like to congratulate you on a great job the team is doing so far. We're not seeing any budget overruns and we're actually seeing a very efficient operation being run. The new technologies you've demonstrated for us today are exactly the reason why we're trying to develop a new rocket system because by developing a new system we're going to force people to come up with new technologies and push the envelope of human understanding a little bit further.

First of all, do we need two X-33s and where does competition come to play in the program?

Colonel PAYTON. There is a flight test risk having a single test article. It would be nice if we could have two test articles of the same design but, unfortunately, the budget that we've been allocated does not give us the room to do that. Additionally, further competition within the X-33 program itself would be terribly expensive also.

So this summer, this July we will select the X-33 design that looks to be the most promising as the advanced technology demonstrator, and we're going to focus all of our resources on that design team, that bird, and concentrate all of our resources on that, so that we can apply the best technology to that single program.

Mr. ROHRABACHER. So, in other words, if we had two companies in competition some of the advances that one company would make would not be used on their experimental model for the other company; is that what you're saying?

Colonel PAYTON. What we've discovered, and it's very understandable, is when companies are in competition they tend to be terribly proprietary with their own not only designs, but what they learn in that program.

Mr. ROHRABACHER. It seems what you're saying is we can't afford what traditionally we've seen in the advancement of aviation, which is fly-offs between companies who have competing aircraft. You say that that's something we're not going to do this particular time. Do you think that's just in the past and we're not going to be able to use that in the future?

Colonel PAYTON. To mitigate some of the risk from a technology viewpoint, for instance, suppose the ceramic tiles don't do as well as we currently think they will, should we continue metallic technology in parallel. We've asked each of the three X-33 teams to identify the most crucial technologies in their particular design and plan and estimate what they should do and what they could do to bring along alternative technologies for those most critical. So again this is different than competitive pressures, but this is the best we can do for carrying along technical alternatives.

Mr. ROHRABACHER. And I suppose that today with our computer capabilities we can actually have fly-offs on the computer, so to speak, with these different designs.

Where do you hope to end up, and I know we're running out of time. So if you could just tell us where do you want to end up with this program and what is America going to have for the investment that we've made, and if we don't reach that goal you will consider yourself a personal failure.

Chairman SENSENBRENNER. The gentleman's time has expired.

[Laughter.]

You don't have to answer, but if you want to, Colonel Payton, go ahead.

Colonel PAYTON. May I answer that one for the record?

Chairman SENSENBRENNER. You may.

[The following information was received for the record:]

The Reusable Launch Vehicle Program aims at sufficient reduction in the technical risk of developing a next generation fully reusable launcher that industry will then make the investment necessary to develop such a vehicle. In the event that the technical risk associated with development of an RLV remains too high for private investment, NASA—and the Government—have several options. NASA could undertake additional technology development to further reduce the risk to a private investor. Alternatively, the Government might conclude that the national interest was best served by some additional Government involvement in the development of a next generation system. Additionally, the Government could undertake to pursue both of these options, or others.

Chairman SENSENBRENNER. The gentleman from California, Mr. Brown.

Mr. BROWN. Thank you, Mr. Chairman.

May I just briefly engage Dr. Morgan in a question.

Dr. Morgan, my memory gets a little hazy at times, but didn't I visit your operation a few years ago?

Mr. MORGAN. Yes, sir, you did.

Mr. BROWN. And is Dr. MacCready still with the organization?

Mr. MORGAN. Yes. He's the Chairman of the Board.

Mr. BROWN. I was interested in your statement, very much interested as a matter of fact, because you seem to be working under a partnership arrangement which is proving to be effective even though it involves several companies that are ordinarily in competition; is that correct?

Mr. MORGAN. Yes, sir. The ERAST program in fact has four competing UAV manufacturers in it, and even though we're competitors and we have competing designs that were prior developed at least partially for other government programs and they're being evaluated against each other, we're also under that agreement sharing information that is gained particularly having to do with operational experiences, and from this we hope to develop the better combinations of propulsion systems, control systems and airplane configurations and materials that we can develop the most possible or probable successor that takes the best of all these different vehicles.

It does look to us that the solution right now will be a vehicle that is a composite design that uses internal combustion engines, that has a bigger payload capacity and more flexibility, and the solar plane would offer sort of the ultimate in duration, range, low cost and altitude. But the solar plane is limited and it cannot operate at the North Pole in the wintertime, and therefore there will be a mix from them.

Mr. BROWN. Do you find not being able to operate at the North Pole in the wintertime to be a terrible barrier?

Mr. MORGAN. It doesn't bother me personally.

[Laughter.]

I could see operating in Hawaii and places like that as not too bad of a duty, but it does therefore give us the mix. For instance, a solar plane uniquely could monitor the spawning of hurricanes off the West Coast of Africa, track them across the ocean for weeks at a time measuring the effluence and looking at the ocean temperatures ahead, and from that predicting landfall, where it might hit and what its strength might be and so forth. But certain science missions have to with just at sunrise at the Poles near the wintertime and so forth like that that the solar plane can't do. So it requires a complement, and there is no easy answer.

Like I said, there are many missions that manned airplanes should do. If you have a heavy payload and it's mature yet and you want to get it up in a hurry, the manned airplane is the right way to go. I can't see UAVs economically competing in the higher weight payloads that go on DC-8s and C-130s right now.

If I can keep talking for just one more second I might point out that the L-1011 was capable of flying as an unmanned airplane in 1973 coast to coast, but nobody in his right mind would suggest we do that. There is tremendous value in having a pilot on board.

Mr. BROWN. Dr. Morgan, I have here in my hand, as Congressmen are frequently prone to say, a document from the Council on Competitiveness which sets forth a rather vivid description of the changes required to be competitive in the world ahead, and it says. A new paradigm of R&D partnerships is emerging based on the collaboration rather than the separation of key participants in the R&D enterprise. What would be your reaction to that? Is that something that you can empathize with?

Mr. MORGAN. I think so. I think quite frankly the UAV industry is very immature compared to the aerospace industry as a whole. If you look back at the history of the development of the airplane in the U.S., it was led initially actually by government funding of the airmail service when it was not really economical to do and that began the commercial airline industry.

The aircraft industry really thrived in the '50s when there was a large interchange of information, the AIAA and other agencies like that. The NACA developed a common base of information. The UAV industry grew up from model airplane guys in a garage who were very parochial in their information.

Mr. BROWN. You don't consider this kind of——

Chairman SENSENBRENNER. The gentleman's time has expired.

Mr. BROWN. Well I'm right in the middle of a question, Mr. Chairman.

Chairman SENSENBRENNER. Go ahead.

Mr. BROWN. You don't consider this kind of a partnership in collaboration to be a form of corporate welfare, do you?

Mr. MORGAN. In a word, no.

Mr. BROWN. Thank you.

Chairman SENSENBRENNER. The gentleman from Texas, Mr. Stockman.

Mr. STOCKMAN. Mr. Morgan, I want to follow up on a question that I was talking earlier about. Regarding the Israelis and the DOD's drones or whatever there have been some difficulties in particularly the DOD's plane. Are you experiencing any of the same difficulties that they have, or are you in a different vein than they were?

Mr. MORGAN. Difficulties, could you be more specific.

Mr. STOCKMAN. Well they cancelled the program. The DOD actually cancelled it because they couldn't get the quantity and the flight that wanted out of their plane.

Mr. MORGAN. Well this is a research and development program fundamentally and it involves flight tests. If it was a given that it would perform as we analyzed, none of that would be necessary. So there is always a risk. It is a risk to develop a UAV, particularly if you're a small company such as we are. There is no way we could underwrite tens of millions of dollars of development to do that. So in that sense there is a risk.

Our particular company has been successful so far in doing what we've said we're going to do, but we also know that we may have failures, and if we don't, then we're not really pushing it.

Mr. STOCKMAN. Well I'm just curious. Have you contacted the DOD?

Mr. MORGAN. The DOD a couple of years ago under the Ballistic Missile Defense Office was the sponsor of this program for the boost phase intercept Scud missile defense.

Mr. STOCKMAN. I guess what I'm saying here is you talked to them about what their failures were so you're not duplicating any of their mistakes.

Mr. MORGAN. We have had made available to us under the ERAST program reports from say the Condor Program and other UAV programs. My company actually has been developing UAVs since the early '80s and we're aware of a lot of those things. We have other UAVs we have done, like the Pointer small hand-launched UAV, that we've delivered to the DOD.

Mr. STOCKMAN. Have you also been speaking with the Israelis on their Drone II?

Mr. MORGAN. Not directly, no.

Mr. STOCKMAN. I guess, and I don't want to drag it out, but I just think it would probably be wise that if you looked at other programs in order not to duplicate or replicate their mistakes because if they already made the mistake maybe we shouldn't.

Mr. MORGAN. We definitely try to avail ourselves of as much information as we can. Oftentimes that's closely held, but to the extent that it's available within the U.S. Government we've tried to avail ourselves and NASA has tried to help with by doing that.

Mr. STOCKMAN. The only thing I have to suggest is maybe look at what the Israelis have done because I understand they're pretty successful in their drones.

I yield back the balance of my time.

Chairman SENSENBRENNER. The gentleman from Indiana, Mr. Roemer.

Mr. ROEMER. Thank you, Mr. Chairman.

Colonel Payton, I have a question to you with regard to the budget. According to the figures that were given to me the RLV budget has been plussed up by about $58 million and the space propulsion initiative by about $42 million, and in order to pay for this total of $100 million the NASA Technology Office was cut by approximately $40 million and then $60 million came out of other cuts in other programs; is that correct?

Colonel PAYTON. The RLV program has a constant number of dollars through its life between now and fiscal year '99. What we had in the prior budget profile as the year-by-year amounts did not put enough money early in the program in order to do the competent design work and early decisions that are necessary to deliver a flight test article like the X-33. What NASA has done and what we have done is rolled money from FY-99 to FY-97 in order to keep the program.

Mr. ROEMER. But regardless of the slope and the timing and whether you needed expedited funds, you still had to bring the funds, even if they were coming out of '99 out of your program.

They had to come out of these other accounts in earlier FY funding cycles, right?

Colonel PAYTON. That's right. So within FY-97 I truthfully cannot vouch for where all the money came from, or where the budget came from, but as part of CODAX[sic] I do know that some of it came from CODAX.

Mr. ROEMER. Do you know of any other cuts to other programs in addition to the ones I enumerated here?

Colonel PAYTON. No, sir. I'm not familiar with those.

Mr. ROEMER. Do you know if any programs were cancelled or eliminated because of the shift in funds?

Colonel PAYTON. To my knowledge, none were.

Mr. ROEMER. Can you get back to me on that question?

Colonel PAYTON. Yes, sir.

Mr. ROEMER. Colonel Payton, certainly the good work that you're doing should be and will be supported by this Committee. There are a number of people that are very supportive of the work you're doing in this Committee and in this Congress. What many of us are concerned about, however, is the cannibalizing effect when this budget is going down that other programs are eating from other programs, and the cannibalizing effect could endanger some safety and security as well, too. So if you could get back to me on those questions I would appreciate it.

[The following information was received for the record:]

It is impossible to state definitively whether or not the rephasing of the RLV program directly caused any specific terminations. The RLV rephasing was accomplished as part of the reallocations and reductions resulting from the OMB passback in February. As directed by OMB, the passback changes netted out to a total reduction of $161 million in FY 1997 funding. The full package of "puts and takes" involved in responding to the passback included the RLV rephasing, while some other, lower priority items were reduced or terminated. Some of these lower priority items would have been cut whether or not changes had been made to the RLV program, but since the rebalancing was done as a package, it is impossible to determine which cuts resulted directly from the RLV rephasing.

Mr. ROEMER. Lastly in terms of following up on some previous questions that were asked about the timing of the RLV in 1999, and hopefully this is going to work as you're planning and everything will come to fruition, what are our options if it doesn't work and what is the time frame for acting upon those options?

Colonel PAYTON. The first flight of the X-33 will occur in March of '99. That will be preceded by the X-34 flight test program which will start in the summer of '98. So during the course of 1999 we'll be collecting an immense amount of flight test data and ground test data to reach a decision on the maturity of these technologies and how they perform in a launch and landing environment, and at that point we could embark upon industry funded full-scale development of an operational bird based on this knowledge that the government has predominantly paid for.

If our knowledge is incomplete, NASA will continue, or has a need to continue launch and transportation technology even beyond 1999. December of 1999 is not a brick wall. It's our job to continue technology development and technology demonstration, and the program you alluded to earlier, the Advanced Space Transportation Program, is the seed corn that we are starting in '97 that would deliver some of the newer technology, different technology for flight test in 2000 or 2001. So what we have laid out is a continuing program of technology demonstration for improving space transportation.

Mr. ROEMER. Thank you.

Thank you, Mr. Chairman.

Chairman SENSENBRENNER. The gentleman from Kansas, Mr. Tiahrt.

Mr. TIAHRT. Mr. Chairman, I would like to yield my time to Mr. Rohrabacher, the gentleman from California.

Mr. ROHRABACHER. Thank you very much.

First of all, let me say that I agree with Mr. Roemer about his concerns that certain programs may be cannibalizing other programs and affecting other capabilities. This is one of the reasons why I have been so concerned about Mission to Planet Earth, along with Dr. Fleeter's comments today about the huge satellites and perhaps being counterproductive.

Obviously as our budget is being looked at, and if you look down the road, when you take a look at Mission to Planet Earth it is going to eat up a potential for any number of new developments.

In terms of what we're talking about here with the X-33 program, the X-33 program is by its very nature designed to come up with new technologies that will keep America not just with the competition, but ahead of the competition, which is exactly where a future oriented program should be. That's how you invest money, and it will bring down the cost once completed of every other project in space that America will be involved in.

I would like to ask General Lord a question.

General, in a recent, I guess it's a study, it's called The New World Vista Study there was a stress, and by the way it took a long time for us to get the Air Force to acknowledge the need for reusable launch vehicles, but in this particular study it stresses the importance of reusables as well as space planes. I wonder if you could tell us and detail for us some of the uses for reusable launch vehicles and space planes for military uses.

General LORD. Yes, sir. We've looked at that as part of our overall, what we call our mission area planning process and, as I alluded to earlier in my remarks, the NASA folks are integrated with us because I think what we can do that will really help leverage the technology dollars that we've got to spend is to make sure that we can state our military requirements as accurately and as definitively as we can so that we can make the most use of the dollars that we have to do that.

In terms of reusable technology in terms of a space plane or that kind of technology, we're looking across our mission areas in terms of where we typically look at force enhancement and making sure that we can do an orbital transfer kind of vehicle, reusable technologies to deliver space craft and to repair space craft, and across all mission areas and really making sure that we can ask the right questions and supply the answers with the technologies.

Mr. ROHRABACHER. Well this technology will provide the military with incredible flexibility, will it not?

General LORD. It appears that that's the case, yes, sir. What we're going to do is we are going to share our operational requirements document that we prepared for the evolved expendable launch vehicle, which really stated our requirements with the folks in the RLV area so that they can take advantage of what our mission needs statements are and mission requirements are in that area.

Mr. ROHRABACHER. Well we are looking forward to making sure that the military plays a part, but also pays a part as well as plays a part of this project. Already we've had a lot of leadership from the military and from Colonel Payton himself and Colonel Warden and Lt. Colonel Sponable[sic], all of whom have done a terrific job, and if 5 or 10 years down the road America has a new launch system, a reusable system that could be a manned system as well that has dramatically brought down the cost of getting into space, this will be a project that is well worth the investment instead of a cannibal project.

However, if 10 years down the road we've spent money on this project and we've permitted it to go over budget or if we permit people to exaggerate on what they can produce, not only will it have been a cannibal project because other projects will have not been funded, but it will be a big waste of money.

I know our Chairman, Mr. Sensenbrenner has seen these projects come through and not meet the expectations or the promises made, and I just want you to know that although I'm a major supporter of this project that I will be working with Mr. Sensenbrenner to make sure that we actually achieve our goals and do what's right by the taxpayer.

Chairman SENSENBRENNER. The gentleman from California got the message.

[Laughter.]

Mr. ROHRABACHER. Thank you very much, and I yield back the balance of my time.

Chairman SENSENBRENNER. Finally, the gentleman from Alabama, Mr. Cramer.

Mr. CRAMER. Thank you, Mr. Chairman.

Colonel Payton, my questions will be for you. I understand that the way you're working with industry on the RLV program will change from the way that NASA has done business. Would you tell me about that and how that is working.

Colonel PAYTON. Yes, sir. We have a self-imposed constraint that 20 NASA people are actually managing the RLV program, managing meaning that those are the people who have the authority to spend the government money. That is limited to 8 at Headquarters and 12 at Huntsville. Right now we're at 19. We're even below the 20.

But that's not the complete number of NASA employees that are involved in the program. Our management structure has limited the number of managers, but has offered the technical capability that NASA has at Huntsville, at Ames, at Langley, at Dryden, at Johnson and at KSC. Each one of the centers is participating in response to industry requests. So each industry team within the 33 program has NASA laboratories, NASA facilities and NASA expertise as part of their team in responding to the schedules and the technical requests from those teams. So instead of burdening industry with a huge number of people to oversee their work, what we are doing is taking that same expertise and making it responsive to the industry requests.

Mr. CRAMER. And that's working well?

Colonel PAYTON. Superbly. Whenever I talk to one of the industry managers from any of the industry teams my first question always is are the NASA employees responsive to you. Very, very early in the program there was one case where they were not, but we fixed that very rapidly and there has never been a squawk from any of the industry managers on either the quality, the quantity or the responsiveness of these NASA teams.

Mr. CRAMER. I want to come back to another point. In your planning and executing of the RLV and the AST how are you making sure that NASA doesn't duplicate transportation technology work already being done by DOD?

Colonel PAYTON. General Lord has talked about at the upper level of the integrated product teams where NASA as an institution and the DOD as an institution are working together, but within the RLV program itself and the AST program we've got even more. For instance, in the X-33 program there is a government program manager who is a NASA individual, but the deputy program manager for flight test is an Air Force officer. So we are using Air Force people and skills and experience within the X-33 and the DC-XA program.

Within the Advanced Space Transportation Program the manager at Huntsville for that program is the NASA representative on something called IPRT, which is the integrated high-performance rocket technology program, IPRT, and what that is is a co-chaired working group where DOD and NASA get together and explain what we are doing with our budgets, with our plans and with our technologies for propulsion, and again the NASA representative, the NASA co-chair for that IPRT is the same individual who is managing the Advanced Space Transportation Program.

Mr. CRAMER. That's all I have, Mr. Chairman. I yield back.

Chairman SENSENBRENNER. Thank you very much. This looks like about as good a time as any to break for lunch. So I would like to thank all members of the second panel for their very good testimony and answers to questions.

I am advised by the Cloak Room that there will be a vote at 12:30 which is not expected to go to a roll call and that we will not have roll calls until 2 to 3 p.m. So what I would like to do is to recess the Committee until 12:30 for lunch and I would ask the Members to be back promptly. If someone does ask for a roll call, then we will start at a quarter to one, but hopefully we will be able to get going at 12:30.

Would the members of Panel 3, which are Dr. Lanzerotti, Dr. Ford, Dr. Friedman, Dr. Hester and Dr. Sargent, please be here promptly.

The Committee is recessed until 12:30.

[The Committee recessed at 12:02 p.m., to reconvene at 12:30 p.m. the same day.]

AFTERNOON SESSION

Chairman SENSENBRENNER. The Committee will be in order.

Let the record show that the Minority party has waived their right to have participation at this hearing. After a 22-minute due and diligent search produced no Democrats, the Republicans will be able to carry the charge all by ourselves.

The Third Panel will be on Space Science, and the witnesses are Dr. Louis J. Lanzerotti, Distinguished Member of the Technical Staff at Lucent Technologies, Dr. Anneila Sargent, Chair of the NASA Space Science Advisory Committee, Dr. Holland Ford, Department of Physics and Astronomy at Johns Hopkins University, Dr. John Hester, Assistant Professor of Physics and Astronomy at Arizona State University and Dr. Louis Friedman, Executive Director of The Planetary Society.

Each of you gentlemen will be recognized for five minutes at a clip, and first up will be Dr. Lanzerotti, who is a Distinguished Member of the Technical Staff at Lucent Technologies.

STATEMENT OF LOUIS J. LANZEROTTI, DISTINGUISHED MEMBER OF THE TECHNICAL STAFF, LUCENT TECHNOLOGIES

Mr. LANZEROTTI. Thank you very much, Mr. Chairman. I am at Bell Laboratories with the new Lucent Technologies spun off from AT&T. I'm one of the very few researchers in industry who has participated in a classical NASA Space Science Program. I've also been very active in numerous engineering issues over the years related to the space environment and its effects on commercial communications satellites.

I would like today to address in a broad way the Space Science Program. Among the forces that have shaped the nation's civil space program and influenced the work of its principal agent, NASA, are two that have changed significantly in recent years. NASA's budget is now declining instead of growing, and U. S. relations with Russia have become collaborative rather than competitive.

Against today's backdrop of budgetary constraints and absent Cold War pressures it makes sense to look anew at what the nation wants to do in space. It is impossible I believe to carry out the full spectrum of space activities that were planned under the assumption of continuing budget growth that was projected in the 1992-'93 time frame, for example. And while the philosophy of working faster, smarter and cheaper should be applied as diligently as is feasible in all endeavors, choices have to be made. Criteria for determining those choices should reflect what we view as our national purposes for going into space as we near the 21st century.

Space science, like much of science, doesn't generally draw attention as an obvious short-term priority for either NASA, the nation, or Lucent Technologies. Undertake no space science, and the nation wouldn't notice for a while. But space science has implications for the kind of society we want to have for our understanding of our place on earth and in the cosmos, for technological spinoffs with direct and present benefit, and I mention one of those, my work in commercial satellites, and for our children's understanding and stewardship of their planet.

Under some accounting this classical space science component of the U.S. civil space program represents some 13.5 percent of NASA's proposed '97 budget. The nation's investment in space science has resulted in an impressive set of achievements that have revolutionized human understanding of the earth's space environment, our solar system, and the planets we share with it and our universe, and I've enumerated a number of those in my written testimony.

In addition, studies of the effects of the radiation environment on communication satellites and of the effects of solar activity for perturbing the earth's space environment have yielded understandings that are very important for several industries, including communications and electrical power. And ahead are rich new opportunities to continue gleaning knowledge from the frontiers of space.

Most space science, classical space science deemed of highest priority to achieve advances important to the nation could be done using robotic rather than piloted spacecraft. Choices of which missions to be undertaken, however, are often effectively limited by cost. Even by working smarter, faster and cheaper it would be difficult, for example, to carry out comprehensive studies of the outer planets given the costliness of designing and monitoring such missions and returning and analyzing the data.

To, instead, study more intensely the earth's space environment and planets closer to earth, such as Venus and Mars, would be less costly alternatives. But achieving value, whatever that might mean, cost effectively is another matter which requires the establishment of priorities for what the space science program should be within the national R&D endeavor as well as within the civil space program itself. Space science is not just one segment of a fragmented program, and I believe we have a fragmented program today.

I believe today's very different financial and foreign relations climate calls for a thorough look at the U.S. Space Program. Just like an industrial organization that has a mission that is agreed upon, and it's mandatory to have such a mission, I do not believe that the nation has such an agreed upon overall mission today for NASA's and the nation's role in space.

If I may not be considered too presumptuous, and if I can be a little blue sky, I would like to suggest that a bipartisan commission be named to examine the total program, the space program carefully and thoughtfully with agreement at the outset from both the Executive and Legislative Branches of government to give serious consideration to the Commission's recommendations. And I say an agreement from the outset because in my testimony I have enumerated two recent Commissions that resulted in conflict between the two branches of government

I would urge this commission to hold the benefits of scientific discovery as a motivating criteria for space activities in the post-Cold War era and to recognize bipartisan cooperation as the means to a result that best benefits the nation and the planet.

Thank you.

Chairman SENSENBRENNER. Thank you, Dr. Lanzerotti.

[The prepared statement of Dr. Lanzerotti follows:]

STATEMENT OF

LOUIS J. LANZEROTTI
Distinguished Member of Technical Staff
Bell Laboratories
Lucent Technologies
Murray Hill, New Jersey

Before the
SUBCOMMITTEE ON SPACE AND AERONAUTICS
of the COMMITTEE ON SCIENCE

United States House of Representatives

April 17, 1996

TESTIMONY REGARDING SPACE SCIENCE AS IT RELATES TO THE U.S. CIVIL SPACE PROGRAM

SUMMARY

Among the forces that have shaped the nation's civil space program and influenced the work of its principal agent, NASA, are two that have changed significantly in recent years: NASA's budget is now declining instead of growing, and U.S. relations with Russia have become collaborative rather than competitive.

Against today's backdrop of budgetary constraints, and absent Cold War pressures, it makes sense to look anew at what the nation wants to do in space. It is impossible, I believe, to carry out the full spectrum of space activities that were planned under the assumption of continuing budget growth that was projected in the 1992-'93 time frame. And while the philosophy of working smarter, faster and cheaper should be applied as diligently as is feasible in all endeavors, choices need to be made. Criteria for determining those choices should reflect what we view as our national purposes for going into space as we near the 21st century.

Space science, like much of science, doesn't generally draw attention as an obvious short-term priority. Undertake no space science, and the nation wouldn't notice for awhile. But space science has implications for the kind of society we want to have, for our understanding of our place on earth and in the cosmos, for technological spinoffs with direct and present benefit, and for our children's understanding and stewardship of their planet.

The space-science component of the U.S. civil space program represents some 13.5 percent -- about $1.86 billion of NASA's $13.8 billion budget for 1997 as proposed. The nation's investment in space science has resulted in an impressive set of achievements that have revolutionized human understanding of the earth's space environment, our solar system and the planets we share it with, and our universe. Milestone achievements include the discovery of the Van Allen radiation belts; the establishment of X-ray astronomy; high-resolution photos of the planets, their satellites and rings; the global weather monitoring and forecasting system; growth in a microgravity environment of very large crystals; age-dating of the Moon with lunar samples; detailed mapping of Earth's polar ozone depletions; precise measurement of the "Big Bang" residual radiation; understanding the effects of microgravity on bone growth and healing in mammals; direct measurements of million-degree solar system plasmas; discovery of the enigmatic, rare repeating gamma-ray bursters; and the finding of ancient and active volcanoes on other planets and satellites. In addition, studies of the effects of the radiation environment on communication satellites, and of the effects of solar activity for perturbing the earth's space environment, have yielded understandings that are very important for several industries, including communications and electrical power. And ahead are rich new opportunities to continue gleaning knowledge from the frontiers of space.

In the context of the total civil space program, the impact of declining budgets on space science is influenced predominately by programs such as the space station and the space shuttle -- large, long-term projects that require a relatively fixed amount of the NASA budget. If, given our national purpose and resources, the space station is deemed vital and is indeed built, there is some important science that could be accomplished using the space station. The space station is not, however, needed for most space science; and to justify it for that purpose would be difficult.

Most space science deemed of highest priority to achieve advances important to the nation could be done using robotic, rather than piloted, spacecraft. Choices of which missions to undertake, however, are often effectively limited by cost. Even by working smarter, faster and cheaper, it would be difficult, for example, to carry out comprehensive studies of the outer planets, given the costliness of designing and monitoring such missions and returning and analyzing the resulting data. To, instead, study more intensely the earth's space environment and planets closer to Earth such as Venus and

Mars would be less costly alternatives. But achieving value, cost-effectively, is another matter, which requires the establishment of priorities for what the space-science program should be within the national R&D endeavor as well as within the civil space program itself.

I believe today's very different financial and foreign-relations climate calls for a thorough look at the U.S. Space Program. I'd like to suggest that a bipartisan commission be named to examine the total program carefully and thoughtfully, with agreement at the outset from both the executive and legislative branches of government to give serious consideration to the commission's recommendations. I would urge this commission to hold the benefits of scientific discovery as motivating criteria for space activities in the post-Cold-War era and to recognize bipartisan cooperation as the means to a result that best benefits the nation and the planet.

SPACE SCIENCE: ITS PURPOSE, FRONTIERS AND RESOURCES

The U.S. invests in space science in order to better understand the place of humans in the universe. Science in space is a central activity of the nation's R&D enterprise. Indeed, under some bookkeeping, NASA's space and earth-science activities comprise about 15 percent of the nation's science and technology (S&T) funding. The kinds of activities supported by the space-science budget include studies of the earth; the earth's space environment (space weather); the Sun and solar system; and stars, galaxies and the universe.

Looking ahead, scientists have identified a number of projects that are of high priority for making important next advances in those areas of concern. There is a great deal of scientific interest, for example, in understanding more about Mercury and in sending a spacecraft quite close to the Sun (meaning some 10 to 20 solar radii) in order to investigate the origin of the solar plasmas that ultimately affect the earth. In addition, the Solar-Terrestrial Probes missions will prove very important for obtaining better understanding of the earth's space weather.

The budget for NASA, as agent of the nation's civil space program, is $13.8 billion for 1997, proposed. Space science is some 13.5 percent of that: about $1.86 billion. Another $1.4 billion supports Mission to Planet Earth, an earth-science program that studies Earth from space to see how the planet is responding to natural phenomena and to human intervention. A large allocation of some $5.36 billion goes to the space shuttle, the program of piloted space-flight that takes people and materials into space and carries out experiments requiring human participation. And about $2.1 billion goes to the space station program to build a space station in collaboration with the Russians and other international partners. Other items in NASA's budget cover R&D related to areas such as aeronautics and space-flight instrumentation and communication.

MAKING CHOICES, EXPLOITING SYNERGISMS

In optimizing NASA's budget allocations, various interrelationships among its programs are significant. The space-station program, for example, will, under its present design, depend on the space shuttle to ferry materials and people back and forth to waystations under construction. Both the space station and the space shuttle are large, piloted, hardware-intensive programs.

The space-station program was begun in the 1980s when the Cold War was strongly influencing space activities as well as foreign policy. Now in the late 1990s, the space station appears an inviolate part of the U.S. program and requires long-term funding that effectively fixes a sizeable portion of NASA's decreasing budget. What has changed since the program's inception, along with budgets, is the foreign-policy dimension of the space station: We now collaborate, rather than compete, with Russia.

Good scientific study can, indeed, be done using the space station, should it be built. Science should not, however, be a primary motivator for the space-station program; most high-priority space science could be done using robotic, rather than piloted, spacecraft.

A program linked closely with space science conceptually but managed separately is Mission to Planet Earth, which studies the chemistry, physics, and biota of our planet through global remote sensing. Begun in the mid-1980s, the program expanded NASA's emphasis on earth science, supporting programs such as the Earth Observing System (EOS) and the Earth Probes missions.

At its genesis, Mission to Planet Earth was linked to the space-station program, also developing at the time. Accordingly, its design assumed very large spacecraft, sized to fill a shuttle bay, with comprehensive instrumentation to study the earth.

The coupling of Mission to Planet Earth with the piloted program became infeasible, however, when the option of launching the shuttle out of the West Coast was cancelled post-Challenger. West-Coast launching is needed for the polar, rather than equatorial, orbit that remote earth-study requires. But though the rationale that linked Mission to Planet Earth with piloted flight no longer existed, the earth-science program's design continued to be based on comprehensive instrumentation carried on a single large spacecraft.

With the current need to tighten objectives, that logic has been reviewed in recent years. Even given these reviews, some observers believe that delays are likely to occur in the launching of some smaller spacecraft, or even some EOS instruments, that are critical for providing continuity of the data streams necessary for good science and good policy decisions. There are also continuing concerns whether good linkages will be made between remote sensing and ground-based and in-situ studies of the earth's surface and atmosphere.

SEEING THE WHOLE PROGRAM

Two important studies during the past decade have looked at the the U.S. Space Program as a whole and made recommendations for its future direction. Both were well designed efforts conducted by knowledgeable and dedicated individuals, and resulted in reports that are well worth citing and learning from.

The National Commission on Space, established at the request of Congress, reported its results in 1986. Its work could be characterized as visionary, ambitious, and focused on piloted flight, including the establishment of humans beyond Earth in the solar system. But with no initial buy-in from the executive branch, its recommendations were not considered seriously by the White House.

In 1990, under the auspices of Vice President Dan Quayle, the Advisory Committee on the Future of the U.S. Space Program (informally called the Augustine Panel) pursued their charter in an intense 120-day study, documented in a report to the Administrator of NASA. The report could be characterized as sober and reasoned, with good rationale across the space program. Application of the report's recommendations, however, unraveled in the rapidly changing budgetary and international climate that followed its delivery at the time.

Given our nation's investment in space, the dramatic world changes that have occurred over the past decade, and the present economic climate, I believe we need a commission jointly sponsored by the legislative and executive branches of government to look anew at our space program, the resources we're committing to it and how those resources could best be allocated. I would urge this commission to hold the benefits of scientific discovery as motivating criteria for space activities for the post-Cold-War era. And I would urge ground-rules that require agreement at the outset from both Congress and the Administration to examine carefully and consider seriously the commission's recommendations. Both groups will recognize that bipartisan cooperation in such an endeavor will serve their interests as well as the nation's.

# # #

Louis J. Lanzerotti

Bell Laboratories, Lucent Technologies

Dr. Lanzerotti, Distinguished Member of Technical Staff, Bell Laboratories, and Adjunct Professor of Electrical Engineering at the University of Florida, has also served as Regents' Lecturer at UCLA. His principal research interests include space plasmas, geophysics, and engineering problems related to the impact of space processes on space and terrestrial technologies.

Dr. Lanzerotti is a co-investigator and principal investigator on several NASA missions, and conducts extensive ground-based and laboratory research on space-related topics. He was Chairman (1984-'88) of NASA's Space and Earth Science Advisory Committee and a member of the 1990 Vice-Presidential Advisory Committee on the Future of the U.S. Space Program. He has also served two terms as Chairman (1988-'94) of the Space Studies Board of the National Research Council and was a member (1991-1993) of the Vice President's Space Policy Advisory Board. He served eight years (1982-1990) as a member of the Polar Research Board of the National Research Council, and two years as member of the Advisory Board for the NSF Division (now Office) of Polar Programs. He has served on numerous other NASA, National Science Foundation, and university advisory bodies concerned with space and geophysics research. Elected to the National Academy of Engineering and the International Academy of Astronautics, he is also a Fellow of the American Geophysical Union, the American Physical Society, and the American Association for the Advancement of Science.

Dr. Lanzerotti has twice received NASA'S Distinguished Public Service Medal. Minor Planet 5504 Lanzerotti recognizes his space and planetary research. He has an engineering degree from the University of Illinois and M.A. and Ph.D. degrees in physics from Harvard. He has published over 450 science and engineering papers, and is co-author or co-editor of three books.

Chairman SENSENBRENNER. Next up will be Dr. Anneila Sargent, Chair of the NASA Space Science Advisory Committee.

Dr. Sargent.

STATEMENT OF ANNEILA SARGENT, CHAIR, NASA SPACE SCIENCE ADVISORY COMMITTEE

Ms. SARGENT. Thank you, Mr. Chairman.

As part of my preparation for this testimony I was asked to consider both the effect of the space science budget on my community, the people I work with, and on, in fact, what is considered a comparison between big science missions and the cheaper, faster missions that we're hearing about now.

I would like to say immediately that I find the nomenclature of big science very much a misnomer in this context, because the big science programs that we have seen from NASA, such as the Hubble space telescope, are indeed big in terms of overall cost. However, they are the stuff of small science, the very big stuff of small science in that hundreds of individuals throughout the country at colleges large and small are able to use such big missions to study astronomical problems of their own choosing, and this allows scientists even at small colleges with limited facilities for research to share in the joy of using a unique instrument to attack front-line problems. And I have to tell you that the beneficial effect of conveying that joy to the students in their classes can really not be underestimated.

I agree that cheaper, faster, better, which means more frequent access to space and distributed risk, is certainly very important, and we ought to be thinking about that, too, because it allows more readily for the development of new technologies that will ensure continuing low costs and high scientific returns in the future.

Individual missions in this program will be less expensive, but it's actually difficult to say right away if the resulting science per dollar will be more or less. We need to bring into this equation the number of scientists who are involved, the connections with industry and the degree of feedback to the American public. They are all very important parts of that equation. It's too early to say what the answer is.

What is clear is that we need such missions for technology development for the simple reason that in the next century, in the next decade we're inevitably going to want to address problems that will require more than small missions. At some point we need a lot of radiation from whatever we're looking at to address the problem. The technological knowledge gained from frequent launches of small missions will be essential to ensuring that any such big project, and again I think that you should look at the word "big" very cautiously, these missions will be essential to ensuring that the most cost effective methods are used in these missions.

Now let me turn to the matter of the budget. It goes without saying that the space science community is deeply concerned about the potential decline in the NASA budget. We have worked with NASA's Office of Space Science to formulate a strategic plan that addresses what we believe are the fundamental questions of our time, but also we work in response to budget realities.

We believe that we can actually deal with decreases because we've been proved to have dealt with them before. If you look at us in the space science community, we have stepped up to the difficulties of the fiscal situation. We have cut back missions, we have restructured missions and in some cases we have accepted complete cuts of missions. We have restructured and our philosophy has always been to do the very best science that we can do within the fiscal reality, and by the very best science I mean what will return most to us and to the American public in terms of excitement and interest.

The problems we're really interested in I've actually listed. How did the universe form? How did the solar system form and develop? Are there other solar systems out there, and what do the planets teach us about the earth and its formation? How does the sun affect our local environment? These are all important problems and the new missions are geared to answer them.

However, in the budget, as we now see it, it will be possible to do the plan that we have set out within perhaps a constraint of maybe a decline of 10 to 14 percent. We can accept the decline that NASA is accepting. We cannot accept a greater decline. Even with a 10 percent decline we'll have difficulty starting up some of the fundamental programs, and by that I mean things like the origins of solar systems that we plan for the next century.

Beyond a 10 or 15 percent decline we are going to have to cut missions at the present, and in that sense we will again impact our community across the country. I remind you of the small people in small colleges teaching our youth who will be affected when missions are cut.

Thank you.

Chairman SENSENBRENNER. Thank you very much, Dr. Sargent.

[The prepared statement of Dr. Sargent follows:]

WRITTEN TESTIMONY

Anneila I. Sargent

1) It goes without saying that the Space Science community is concerned about the potential decline in the NASA budget. During the next few years we expect to undertake the groundwork that will lead to successes in the twenty-first century. With this goal in mind, we have worked with NASA's Office of Space Science (OSS) to formulate a Strategic Plan that provides this foundation and, at the same time, responds to budget realities. If we can carry out this plan, we believe we can continue to address the outstanding scientific questions of today and, just as importantly, continue to bring the excitement of scientific exploration to the public. An important element of the plan involves technological development that is intended to increase efficiency and reduce costs for future missions. This is critical to maintain the vitality and strength of space science in the next century.

The Space Science community is prepared to deal with a budget that declines in proportion to the rest of the NASA budget. We have already responded to the changing fiscal environment by restructuring, downsizing, and sometimes accepting the elimination of programs. We are also enthusiastic about NASA's new technology programs which should allow us to continue to expand our horizons in a cost-effective way. To date we have managed to accomplish reductions in cost, while maintaining the capability to carry out the exciting science that the Nation has come to expect of NASA missions by, focussing on carefully-selected problems that we believe are of fundamental importance to the human race:

How did the Universe form and develop?

How did our Solar System form?

Are there other planetary systems?

What can the other planets tell us about Earth and the way it evolved?

Can we improve our understanding of how the Sun affects Earth and its inhabitants?

We are grateful that within the confines of the proposed 1997 Budget, we can continue to move forward with our plans to attack these questions. We are excited about the avenues that are opening up. However, the fiscal situation in the ensuing years is less clear. We believe the current Strategic Plan can be carried out even if the Space Science budget declines by as much as 13 - 14% over the next few years; it cannot be completed if the decrease is of order 20%. Even the lower rate of decline will have a severe impact on the space science community and its efforts to explore our universe and share the bounty of knowledge and excitement with the American public; although the Strategic Plan as currently envisaged could indeed be carried out, there is no possibility of substantial investment in missions beyond that. Space science in the twenty first century does seem to be in jeopardy.

2) I have been asked to compare NASA's "former big science missions" to its current "cheaper, faster, better" missions in terms of ultimate science per dollar. In this context, I find the nomenclature "big science" something of a misnomer. Programs such as Hubble Space Telescope are indeed big in terms of overall cost. However, they are also the stuff of "small science" in that hundreds of individuals at Colleges large and small, throughout the Nation are able to use HST to study astronomical problems of their own choosing. This allows scientists at even small Colleges, with limited facilities for research, to share the joy of using a unique instrument to attack front-line problems. The beneficial effect of conveying that enthusiasm to students in their classes cannot be underestimated.

"Cheaper, faster, better" essentially means more frequent access to space and distributed risk. It also allows more readily for the development of new technologies that will ensure continuing low costs and high scientific returns in the future. Individual missions will be less expensive but it is difficult to say if the resulting science per dollar will be more or less. The number of scientists actively involved, the connections with Industry, and the degree of feed-back to the American public are all important parts of the equation and it is still rather early for a definitive answer. What is clear is that the technology development which is an integral part of this way of doing business is critical to the future success of space science. In the next century, we are inevitably going to want to address some problem that will require more than cheaper, faster, missions. The technological knowledge gained from the frequent launches of small missions will be essential to ensuring that any such project is carried out in the most cost-effective way.

Chairman SENSENBRENNER. The next witness will be Dr. Holland Ford of the Department of Physics and Astronomy at Johns Hopkins University.

Dr. Ford.

STATEMENT OF HOLLAND FORD, DEPARTMENT OF PHYSICS AND ASTRONOMY, JOHNS HOPKINS UNIVERSITY

Mr. FORD. Chairman Sensenbrenner and Mr. Weldon, I am pleased to have the opportunity to discuss with you NASA's declining budget for space science.

The effects of the decreasing budget are already painfully visible at the Johns Hopkins University. Young and not-so-young astronomers are seeing the end of their programs, their employment and in some cases their careers as astronomers. Astronomy has begun a downsizing with many of our best and brightest leaving the field. After three years as a prestigious Hubble Postdoctoral Fellow one of my best graduate students is now working in a bank, an honorable profession I would add.

The declining NASA budget will inevitably curtail both large and small space science. In my view, some of the most fundamental questions asked by human beings can be answered only with large space programs answering the question—is there life on other planets—and fulfilling Dan Goldin's vision of directly imaging earth-like planets will require large and expensive telescopes in space. Nonetheless, his emphasis on faster, cheaper, better does present opportunities for solving old problems in new ways.

With your indulgence, I will briefly discuss an example of one such idea. Putting large telescopes into space is very expensive. In contrast, a telescope larger than Hubble can be flown for several years in the space-like polar stratosphere for a cost of approximately $100 million, a cost that is much less than that of a single heavy-launch vehicle.

A four-meter diameter telescope flying at 40,000 feet in the cold, dry, stable polar stratosphere would see closer to the beginning of the universe than either Hubble or the largest ground-based telescopes. A polar stratospheric telescope, referred to as POST, would enable frontier science that addresses two of NASA's key science themes, the origin of planets and the origin of galaxies.

Large telescopes can be flown in the polar stratosphere by combining two breakthrough technologies, high-altitude tethered aerostats and large, ultra-light telescopes. The aerostat is an aerodynamically shaped hull the length of a football field which is filled with inert helium. The aerostat is attached to a mooring station and large wench by an ultra-strong, seven- mile-long Kevlar cable.

The aerostat can carry two tons to 40,000 feet in 90 minutes and be recovered in a comparable time and can stay on station for up to three weeks at a time. The aerostat would fly an existing, available, recently declassified, ultra-light four-meter telescope. This very same telescope was recommended by an NRC study group for a space astronomy mission following a DOD mission.

POST would be a fast-track, inexpensive stepping stone filling the gap between Hubble and the next generation space telescope, that is NGST. POST would test and demonstrate NGST technologies in the next best place to space, the polar stratosphere and simultaneously continue the stream of stunning images and science provided by Hubble. This proposal is supported by an international team of American, Australian, Dutch and Italian astronomers, engineers and geophysicists.

After careful consideration of polar sites in both hemispheres we conclude that Fairbanks, Alaska, is an excellent site for POST. Contingent on funding from our international partners, after five years of operations at Fairbanks we would most POST to the best polar site in the world, the high, dry and extremely cold Antarctic plateau.

In closing, I think it is important to sufficiently fund space science to provide a secure future for our best young scientists. I also think it is important to be willing to consider new ways to do space science. If the Subcommittee thinks that POST may be one such idea, we recommend that the National Research Council be asked to make a critical study of this proposal. We also recommend a parallel one-year program of engineering analysis and site testing near Fairbanks, Alaska, to provide data to the NRC study group.

Thank you, Mr. Chairman.

Chairman SENSENBRENNER. Thank you, Dr. Ford.

[The prepared statement of Mr. Ford follows:]

Testimony for the U.S. House of Representatives

Subcommittee on Space and Aeronautics

Holland Ford
April 17, 1996

1. Tethered Aerostats and Polar Stratospheric Telescopes

Chairman Sensenbrenner, Ladies and Gentleman of the Subcommittee on Space and Aeronautics. I am pleased to have the opportunity to discuss with you NASA's declining budget for space science.

The effects of the decreasing budget on the research staff at Johns Hopkins University are already painfully visible. Young, and not so young, astronomers are seeing the end of their programs, their employment, and in some cases their careers as astronomers. Astronomy has begun a down-sizing with many of our best and brightest leaving the field. Highly talented Post-doctoral fellows have left Hopkins (and Cal Tech) for positions in investment banking. One of my best graduate students is now working in a bank after three years as a prestigious Hubble Postdoctoral Fellow.

The declining budget will inevitably curtail both large and small space programs. In my view, some of the most fundamental questions asked by human beings can be answered only with large space programs. As an example, Dan Goldin's vision of directly imaging earth-like planets will require large and expensive telescopes in space. Nonetheless, the administrator's emphasis on "faster, cheaper, better" does present opportunities for innovative ideas to use new technologies to solve old problems in novel ways. With your indulgence, I will discuss an example of one such new idea.

Putting large telescopes into space is very expensive. In contrast, a telescope larger than Hubble can be flown for several years in the space-like polar stratosphere for a cost of approximately 100 million dollars, a cost much less than that of a single heavy launch vehicle. A 4 meter diameter telescope flying at 40,000 feet in the cold, dry, stable polar stratosphere would see further into the early Universe at infrared wavelengths, where newly formed galaxies are most visible, than either Hubble or the largest ground-based telescopes. A polar stratospheric telescope (POST) would enable frontier science that addresses two of NASA's four major science themes, the origin of planets, and the origin of galaxies.

Large telescopes can be flown in the polar stratosphere by combining two breakthrough technologies: high altitude tethered aerostats and large, ultra-light telescopes. The aerostat is an aerodynamically shaped, composite-fabric hull the length of football field which is filled with inert helium. The aerostat is attached to a mooring station and large winch by a tapered, ultra-strong, 7 mile long Kevlar tether. The aerostat can carry two tons to 40,000 feet in 90 minutes, and stay on station for up to three weeks at a time. The aerostat would fly an existing, available, recently declassified government ultra-light 4 meter telescope. POST would be a fast-track, inexpensive stepping stone filling the gap between Hubble and the Next Generation Space Telescope (NGST). POST would test and demonstrate NGST technologies in the next best place to space, the polar stratosphere, and simultaneously continue the stream of stunning images and science provided by Hubble. Simultaneously, the aerostat could be used for long term monitoring of chemical pollution in the stratospheric air which controls the Earth's protective ozone layer. This proposal is supported by an international team of American, Australian, Dutch, and Italian astronomers, engineers, and geophysicists.

After careful consideration of polar sites in both hemispheres, and balancing cost against science return, we conclude that the Poker Flats Research Range north of Fairbanks Alaska is an excellent site for POST. Contingent on funding from our international partners, after 5 years of operation at Fairbanks, we could move POST to the best polar site in the world, the high, dry, and extremely cold Antarctic plateau. Recent advances in aerostat technology also enable the possibility of flying the stratospheric telescope from mountain tops in Hawaii and the continental U.S. at altitudes of 65,000 feet, above the jet stream.

In closing, I think it is important to sufficiently fund space science to provide a secure future for our best young space scientists, and to continue to attract talented young people into space science. I also think it is important to be willing to consider new ways to do space science. If the subcommittee thinks that using tethered aerostats as high altitude platforms for infrared observatories may be one such idea, we recommend that the National Research Council be asked to make a critical study of this proposal. The Ballistic Missile Defense Organization funded a similar NRC assessment of the very same telescope as a "New Technology Orbital Telescope." We recommend a parallel one-year program of engineering analysis, and "site testing" at the Poker Flats Research Facility near Fairbanks Alaska to provide data to the NRC study group. The FY 97 cost to start this program, aimed at flying a 4 meter telescope by 2001, would be approximately 2 million dollars.

2. Tethered Aerostats

Tethered aerostats allow heavy (~ 2 tons) payloads to be lifted to 40,000 feet into the pristine, space-like polar stratosphere. Tethered aerostats, which so far have not been used as scientific platforms, are widely used for surveillance. The aerostats approach the convenience of mountain top observatories. Tethered aerostat systems are very rugged and can be left flying for several weeks at a time. Typically, the aerostat is brought down for inspection, helium replenishment, and instrument maintenance every two or three weeks. Downtime is minimal, on the order of a few hours total. Similar vehicles have a long successful record in U.S. Customs and Defense service. The time required to winch the aerostat up or down is approximately one hour and twenty minutes. Thanks to their sturdy and resistant envelope material, aerostats have long lifetimes, typically 10 years or more. These vehicles have logged over 250,000 flight hours without a single loss. The characteristics of a tethered aerostat capable of lifting a two-ton payload to a 40,000 feet altitude are given in Table 1.

Table 1. Aerostat characteristics

Maximum flight altitude	40,000 feet
Overall length	90 meters
Volume	32000 cubic meters
Aerostat mass	5700 kilograms
Tether	15 mm diameter. Kevlar
Tether linear mass	0.15 kilograms/meter
Tether mass at 40,000 feet altitude	1800 kilograms
Power requirement on station	500 watts
Power requirement during descent	5 kilowatts
Retrieving and launching speed	150 meters/minute
Envelope lifetime	> 10 years
Payload 2 tons	

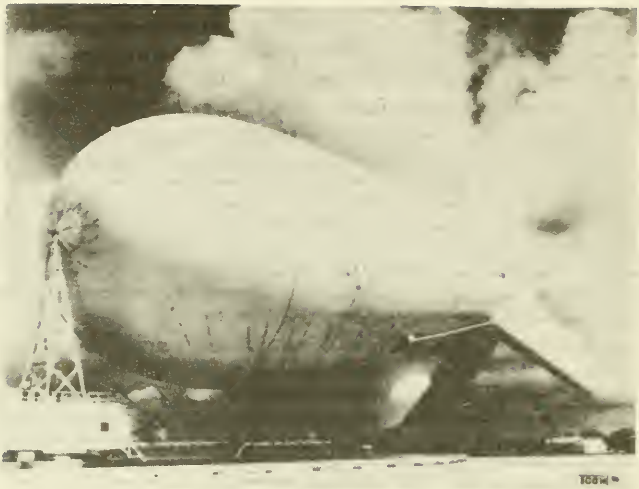

Fig. 1.— A TCOM 71 meter aerostat on its mooring station.

The largest tethered aerostat commercially available, the 71M model from TCOM L.P. (a Maryland company), could not reach an altitude much higher than 20,000 feet. However, there is no fundamental limitation on increasing the size. Although the proposed 90-meter aerostat would be the largest and highest tethered aerostat ever built, the extrapolation does not require new technology, simply a larger envelope. It is also worth noting that such a structure would still be small compared to the Zeppelins of the 1930's.

The Ballistic Missile Defense Organization recently sponsored a study by the Johns Hopkins University Applied Physics Laboratory and TCOM which concluded that spherical tethered aerostats could lift heavy payloads to altitudes of 65,000 feet. This is truly a breakthrough technological capability since such aerostats would allow telescopes to be flown in the stratosphere from mountain tops anywhere in the world. There are many mountain tops in Hawaii and in the continental U.S. that would be excellent sites for high altitude aerostats. Furthermore, this technology has significant dual use potential for the United States since it is of keen interest to members of the Intelligence Community.

3. The Telescope

Recently declassified technology developed by ITEK (now a subsidiary of Hughes Danbury) for a government agency shows a clear path to large, ultra-lightweight, filled mirrors. Hughes has learned to fabricate and polish mirrors with diameters of 4 meters and thicknesses of 17 mm. A 4 meter diameter sheet can be a single mirror, or, after cutting and polishing, a segment of an 11 meters (diameter) mirror! To support these thin mirrors, Itek has developed actuators which have an unprecedented resolution of 6 trillionths of a meter (6 picometers). Two facesheets and 140 actuators were combined in a prototype 4 meter telescope (the ALOT telescope) made entirely of graphite epoxy. Itek demonstrated that they could align the two sheets (comprising ~60% the area of a filled 4 meter telescope) and optimize the figure of the

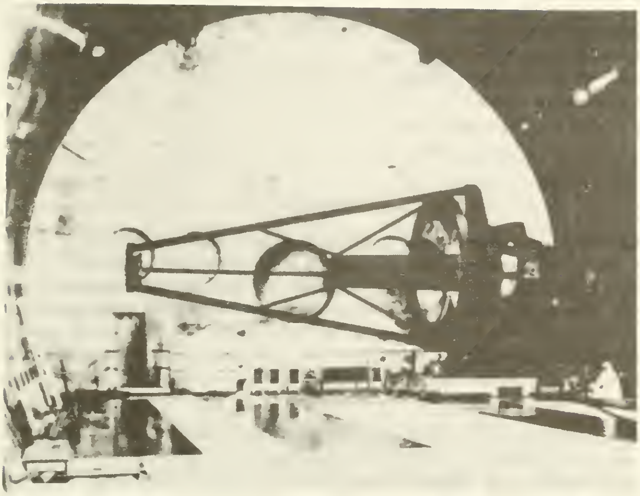

Fig. 2.— The 4 meter telescope we propose to fly, photographed during testing in a large vaccuum tank at Itek (Hughes Danbury).

mirror, achieving lambda/10 performance at optical wavelengths. The entire telescope weighs less than two tons. We propose to replace the incomplete mirror with a single filled 4 meter ultra-light mirror and fly the telescope on top of a tethered aerostat located at the Poker Flats Research Range north of Fairbanks Alaska. By making maximum scientific use of technology funded (for several billion dollars), developed, and demonstrated by the government, we will save NASA and the scientific community a large amount of money and development time. Our operation of a 4 meter telescope in the polar stratosphere will prove the technological principles necessary to insure that NASA and the United States maintain the lead in large space telescopes for the foreseeable future.

4. The Polar Stratosphere

The polar stratosphere is the next best place to space for a telescope. There, the atmosphere is so tenuous that air turbulence, which imposes so many limits on ground telescopes, is essentially non-existent. There, the low air temperatures combined with altitude and the complete shadowing from the sun in winter allows observations in the near-infrared in conditions approaching those in space. In contrast, infrared observations from the best terrestrial sites such as Mauna Kea are limited by the warm ambient temperature (T ~ 32 F), atmospheric transparency set by the residual water vapor above the observatory (~1 to 2 mm precipitable), and by the turbulence in the jet stream at the boundary between the troposphere and the stratosphere. The tropopause boundary at temperate latitudes is at altitudes between 52.000 and 59.000 feet, whereas at polar latitudes the boundary is at an altitude of 26.000 to 33.000 feet. Above the tropopause boundary the polar stratosphere is more than 10 times drier than Mauna Kea (less than 10 microns precipitable water vapor), much colder ($T \sim -126°$F to $-90°$F), and the measure of atmospheric stability and image sharpness is more than seven times larger. We calculate that a 4 meter telescope in the polar stratosphere will see stars and galaxies more than six times fainter than can be seen with the infrared Gemini telescope at Mauna Kea. Because the Hubble telescope is relatively small (2.4 meter), warm ($T \sim 60°$F), and has high thermal emissivity mirrors, POST would see stars and galaxies more than 25 times fainter and 1.7 times sharper than Hubble can see at wavelengths longer than 2.2 microns.

5. The Site

The location of the observatory does not matter much as far as observing conditions in the stratosphere are concerned. This is because the stratosphere, contrary to the troposphere, is essentially decoupled from ground influence. However, as already noted, the altitude needed to fly above the tropopause is much lower at polar latitudes than at temperate latitudes. Consequently, we have studied polar sites, which require less tether length, and thus allow us to fly heavier telescopes. In the Antarctic, conditions in the lower stratosphere are generally more stable than in the Arctic, with lighter winds, and temperatures colder by about 36°F. However, conditions on the ground are much harsher and access and logistics are markedly more difficult.

After careful consideration of polar sites in both hemispheres, we conclude that the best balance between cost and science return will be achieved by first stationing POST at the Poker Flats Research Range north of Fairbanks Alaska. Fairbanks is easily reached by commercial airlines. The Research Range, operated for NASA by the University of Alaska's Geophysical Institute, has ample space for siting the aerostat, and the Geophysical Institute would provide the necessary infra structure for operating the aerostat and observatory.

Contingent on funding from our international partners, after five years of operation at Fairbanks, we would move POST to the best polar site in the world, the high, dry, and extremely cold Antarctic plateau. The telescope also could be used on high altitude aerostats at temperate latitudes to extend the sky coverage.

6. The Science

We plan to use POST to attack two outstanding problems, the origin of galaxies and the origin of planetary systems , both essential but poorly understood preconditions for the origin of life. To detect faint planets in the glare of the parent star, the telescope must provide sharp, high contrast images. POST will provide nearly perfect images (diffraction limited) at 2 microns (and longer wavelengths). Glare from the bright parent star which washes out the light from the faint planet will be minimized by using an ultra-smooth mirror and a coronagraph to block the light from the parent star. We will use the coronagraphic camera to search for Jupiter-like planets and proto-planetary disks.

Near infrared observations permit red-shifted starlight from galaxies forming in the early (ancient) universe to be observed with extremely low interference from light scattered by the particles in our atmosphere and in the solar system. By detecting infrared-bright galaxies which are too faint to be seen with Hubble we will determine whether or not galaxies formed in the first billion years after the birth of the Universe. We will use POST to trace the changes in the rates of star formation within galaxies and the changes in shape as the galaxies age from young to old. We will observe the formation of clusters of galaxies and investigate the distribution and evolution of dark matter in clusters via gravitational distortion of galaxies behind the clusters, as predicted by Einstein. By using POST to detect the brilliant explosions of extremely distant supernovae, we will determine whether the universe is open or closed.

7. The International Science Team

The POST science team includes astronomers, scientists, and engineers from the Geophysical Institute at the University of Alaska, the University of Arizona, the University of California Santa Cruz, the University of Chicago, the University of Colorado, the University of Hawaii, the Johns Hopkins University, the Leiden Observatory in the Netherlands, the University of Rome, the Space Telescope Science Institute, and the Mount Stromlo and Siding Spring Observatory in Australia.

The government and industrial partners include scientists and engineers at Ball Aerospace, Hughes Danbury, the Marshall Space Flight Center, and TCOM.

8. Recommendations

We think that tethered aerostats have such promise as platforms for high altitude, infrared observatories that the National Academy should make a critical study of this idea. We recommend a parallel one-year program of engineering analysis, and "site testing" at the Poker Flats Research Facility near Fairbanks Alaska. The site testing would measure the atmospheric stability and sky brightness in the polar stratosphere. The engineering analysis would look at critical design questions such as mounting the telescope on the aerostat, mirror control and figure, and telescope pointing and control system, and would establish accurate estimates of the program cost. The FY 97 cost to start this program, aimed at flying a 4 meter telescope by 2001, would be approximately 2 million dollars. Because of the potential for joint use, we further recommend that the Department of Defense and NASA should be asked to jointly evaluate high altitude aerostats (65,000 feet).

Chairman SENSENBRENNER. The next witness will be Dr. John Hester, Assistant Professor of Physics and Astronomy at Arizona State University.

Dr. Hester.

STATEMENT OF JOHN HESTER, ASSISTANT PROFESSOR OF PHYSICS AND ASTRONOMY, ARIZONA STATE UNIVERSITY

Mr. HESTER. Thank you very much, Mr. Chairman, for this opportunity to address the Committee.

I would like to step back a little bit and offer a little perspective on what we're talking about. If you look at our time from the perspective of a future historian two or three hundred years downstream, much of what dominates our every-day life, the things that we're concerned with on a day-to-day basis, will be long forgotten.

On the other hand, you can guarantee that one of the things that our time will be remembered for is a time when man first started to reach out with the human mind and the human spirit and start to understand something about this universe that we're a part of. The insights that we're getting out of that process are phenomenal.

For example, we don't have the luxury of going back five billion years and watching as our solar system and our earth formed. What we can do and what we are doing is looking out, as we did in this image of the Eagle Nebula taken with a space telescope, and watching the process of star formation in the universe around us. And as we do that we're coming to realize that our existence, our own solar system is a natural byproduct of that ongoing process.

Actually it gets more personal than that. We now understand that early in the universe there was hydrogen and helium and a little bit of lithium, but that's not what you and I are made of. We're made of carbon and nitrogen and oxygen and such as that, and we now realize that those heavy elements were actually manufactured in the nuclear furnaces in the interiors of stars blasted back out into interstellar space and then incorporated in the cloud of gas and dust that our solar system formed from.

Look around you in the room. Everything that you see was once a part of a star. That's the kind of insight that we're gaining. It's every bit as fundamental and as moving as the insight that Copernicus had when he dislodged the earth from the center of existence. It's also inspirational.

If you want to see the significance of this go out as I do quite often and talk to undergraduates, talk to public audiences, talk to elementary school children. If you want to know the product of this go and talk to a group of urban fifth-graders who don't have a clue where they're going with their lives and show them pictures like this and talk to them about what it is that we're doing and look at their faces as their eyes light up, as they get enthusiastic, as they ask questions, and at the end of that when you say who thinks that it would be a neat thing to be a scientist you see all these kids raise their hands and say I would. If you want a product from space science, that product is our future.

Concerns, I have a lot of concerns. You've heard from many folk that the downsizing that we're experiencing, some of it we could take, and we're basically to the point where we can't take an awful lot more. The morale is low and its getting lower.

The other concern is that as we go to faster, better, cheaper that we're running into some physical limitations. You can't do the kind of work that has been done with space telescopes with small instrumentation, unfortunately. You need large telescopes. You need large telescopes because of their big light buckets. They have to collect light. You need large telescopes because their ability to resolve things that are very close together depends on the size of the instrument. That's physics and you can't get around it.

The other concern is that as we're entering a time when competition for resources becomes tougher, that an easy thing to do is to say that flying the next mission is the priority, but that the science is contingency, that the science is where you can get your money from. That's awfully shortsighted. This picture, that's mission operations and data analysis.

A final point in closing. I started out talking about the perspective of that future historian. Enough has happened in the closing years of the 20th Century that I think that we have submitted our place in history as a time when we started this wondrous journey.

The thing that scares me is that the opening years of the 21st Century are going to be remembered as a time when we lost our spirit, as a time when we became so obsessed with looking inward that we no longer bothered to look outward, and I think that would be a great sadness.

Thank you.

Chairman SENSENBRENNER. Thank you, Dr. Hester.

[The prepared statement of Mr. Hester follows:]

Testimony prepared for the House Subcommittee on Science

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17 April, 1996

From the standpoint of a historian looking back on the Twentieth Century from the perspective of a few hundred years in the future, much of what dominates our everyday concerns will be forgotten. "Big stories" like the O. J. Simpson trial will be forgotten, except possibly by cultural anthropologists interested in what they have to say about our time. On the other hand, just as we remember the Renaissance for the work of Copernicus, Kepler, Galileo, and Newton, every school child will know of the last half of the Twentieth Century as a time when we took our first faltering steps beyond the world of our birth, and as a time when the human mind reached out and first began to comprehend the reality of the larger Universe and our relationship to it.

It is easy to lose track of the fact that we are living in the middle of the most fantastic advancement of human knowledge and understanding in history. Advancement in astronomy is one part of this explosion in understanding. "Unanswerable" questions about the nature of space and time and the origin and fate of the Universe -- long the purview of philosophers -- have become the subjects of rigorous scientific investigation. For example, while we do not have the luxury of going back 5 billion years and watching as our own Sun and Solar System form, we can look out at the Universe around us and watch the birth of new stars, and old stars as they finish their lives and die. What we are finding is that our Solar System -- our very existence -- is a natural side effect of the cycle of star formation and star death that is going on throughout our Galaxy and the observable Universe. Today we understand that the very atoms in our bodies were forged in the nuclear furnaces in the hearts of previous generations of stars, then blasted back into interstellar space by tremendous explosions. Our Sun and Solar System formed from a cloud of gas and dust that carried the chemical legacy of those earlier generations of stars. It is sometimes said poetically that, "We are star dust." But this is not poetry. Everything in this room was once a part of a star.

Astronomy is generally thought of as a science concerning what is "out there," but increasingly we are coming to appreciate the fact that *we are part of what is out there.* I believe that our future historian might find this growing awareness of our connectedness to the larger Universe to be as remarkable and culturally significant as the change in perspective brought about by Copernicus when he dislodged the Earth from the center of existence.

Space astronomy will figure prominently in the story our future historian has to tell. Space astronomy missions have opened up entire new windows on the Universe at wavelengths that cannot be reached from the ground, and today at wavelengths from the ultraviolet through the infrared the *Hubble Space Telescope* is providing an often surprising view of the Universe that is many times sharper than previously available.

As members of the science team associated with the second Wide Field and Planetary Camera (WFPC2), many people asked us after the *HST* service and repair mission if it was "worth it." The only honest answer that we could give at the time was to advise them to "wait and see." "If in a year or two *HST* is having the impact on astronomy that we think it will", we would say, "then it was worth it."

Today, I think it is safe to say that *HST* has more than satisfied our criterion for success. Attend almost any astronomical conference and you will find *HST* results at the forefront of what people are talking about and scratching their heads over. At the edge of the Universe, *HST* is watching as galaxies form and merge, pushing back our knowledge of the history of the Universe to ever earlier epochs. *HST* is successfully contributing to the problem for which it was named, providing much improved distances to galaxies, and in the process helping to establish the scale of the Universe. Closer to home, *HST* is providing a qualitative improvement in our understanding of populations of stars in myriad environments, and is giving us a front row view of a wealth of physical processes that were only hinted at from the ground. *HST* is also allowing us to monitor our neighbors in the Solar System, providing, for example, astonishing views as fragments of Comet Shoemaker-Levy smashed into the atmosphere of Jupiter.

It has only been two years since the repair of the *Hubble Space Telescope*, but already it is hard to imagine ever again doing astronomy without an instrument with the capabilities of the *HST*.

But it is not necessary to attend scientific meetings to see the impact that *HST* is having. Thumb through copies of Time or Life or Newsweek over the past year or so and see the impact that *HST* is having on our culture. I was the lead investigator on the *HST* images of the Eagle Nebula released in November. Since that time I have had numerous opportunities to talk with public audiences about astronomy and *HST*. I have also heard from literally hundreds of individuals from diverse walks of life, from school children to grandparents. In the process, I have been amazed by the level of interest and support that exists for this work. Almost everyone I have heard from has wanted basically the same things. First, they have wanted to say how much this work meant to them. Almost all have said something along the lines of, "when I looked at the pictures I was awestruck, and when I thought about what it was I was looking at, it sent shivers up my spine." Almost all also have spoken of how glad they are that we have this capability, and have admonished us to "keep up the good work." The other questions that almost everyone who has written or called has asked are, "Where can I find out more?", and, "What's next?"

So far I have talked primarily about the impact and cultural significance of space astronomy in general, and *HST* in particular. I have done so, because I think that from the perspective of the policy maker or the professional scientist, we often lose sight of the real reasons for doing these things. But I would also like to take this opportunity to raise two concerns.

Initially, in response to budget pressures NASA is moving toward missions that are often described as "faster-better-cheaper." In most respects I believe that this movement is commendable. For example, it is clearly a desirable goal to improve the efficiency with which we carry out space astronomy and space science missions. In particular, the history of space projects is filled with cases where the cost of a project was run up because an expensive "marching army" was on the payroll, but was unable to actually accomplish anything because of uncertainty in the status of the project. Reducing the number of years between the inception of a project and flight would greatly improve the efficiency of the process. It is also true that by limiting the complexity of missions -- not trying to make a single mission all things to all people -- that the ratio of costs to capability can be improved. Finally, if these goals are to be accomplished it will require that mission planners be willing to accept some degree of risk, which in turn will require a change in the culture surrounding flight projects.

On the other hand, there are dangers in carrying this theme too far. In order to carry out the types of science that make space astronomy worthwhile, spacecraft must sometimes be physically large. There are two reasons for this. The first is that the objects under study are often extraordinarily faint. Telescopes are first and foremost "light buckets" -- the larger the bucket the fainter the object that it can work on. The second reason has to do with the physics of how telescopes work. Probably the main advantage offered by the *HST* is that by getting above the Earth's atmosphere it offers astronomers a sharp and steady view of astronomical objects. Approximately 100 individual *HST* star images would fit within the "blur circle" of a single star as seen under moderately good ground based conditions. But because of the wave nature of light, the resolving power of a telescope is directly proportional to the size of the telescope's primary mirror. Make the *HST* half its current size and you have reduced its resolving power by a factor of 2, which means that you have reduced the number of stars that can be resolved in a given region by a factor of 4. In short, in order for space-based missions to continue to make important contributions to astronomy will require the telescopes flown to be large.

So, while "faster-better-cheaper" is a desirable theme, we should stay in touch with the reality of the situation. As much as they might like to try sometimes, all of the policy makers in Washington cannot change the laws of physics. The laws of physics say that in order to do the sort of science that needs to be done requires that at least some spacecraft be large.

The other concern that I would like to raise is that "flying spacecraft" is not the same as "doing science." Spacecraft are not flown for the sake of flying spacecraft, or at least they shouldn't be. Rather, spacecraft are flown because they can help us learn things about the Universe that are worth knowing. Accomplishing this goal requires time and effort on the part of scientists. Flying missions, then stacking the data in a corner is an empty exercise. *Scientists are not contingency, and Mission Operations and Data Analysis is not a bank to be robbed any time a flight project is squeezed for cash!* The public has seen many rockets fly, and is far less enamored of them than they once were. On the other hand, what the public *is* interested in are new insights and discoveries that give them pause for consideration and reflection.

Anyone who doubts the value of space science and space astronomy to this nation should go and spend an afternoon talking to a classroom full of 5th graders, as I did a few days ago. Those 5th graders understand what this is about, and why it is significant. It is a joyful experience to see their eyes light up as they listen to what the *HST* is doing. Their enthusiasm is contagious as they respond with more questions than could ever be answered in a afternoon. And it is extremely rewarding when at the end of an hour a class full of kids who might not have a clear idea of where they are headed all raise their hands when asked "who might like to become a scientist some day?" That is an experience that cannot be conveyed in words, but is at the heart of the real reason for doing space astronomy.

Such experiences are common to anyone who talks with the public regularly about this work. One of the most moving letters that I have received in the last few months was from a poor Black man living in rural South Carolina, who wrote me to ask for any materials that I could send him. In his letter he explained that his fascination for science and astronomy has been an important part of his life, and that he was active in his community using young people's fascination with space as a way to show them that there is more to the world than the daily existence that they know.

The work that we are doing is not only *educational* -- it is *inspirational*. And it is providing inspiration at a time when inspiration is desperately needed. It is a good and noble thing that our nation can rightly take pride in. Returning to the perspective of our future historian, our accomplishments are many, and the Twentieth Century has earned a place in the history books as the time when the human race began to seriously contemplate its place in the Universe. But what of the Twenty First Century? Will it be remembered as a time when this grand adventure continued on? Or will it be remembered as a time when we lost our spirit; a time when we became so inwardly directed that we could no longer be bothered to look outward? The answer to that question is largely up to you.

Chairman SENSENBRENNER. Finally Dr. Louis Friedman, Executive Director of the Planetary Society.

STATEMENT OF LOUIS FRIEDMAN, EXECUTIVE DIRECTOR, PLANETARY SOCIETY

Mr. FRIEDMAN. Thank you very much, Mr. Chairman. I appreciate the opportunity to once again be at this Committee. I have a full statement which I've sent in for the record and I only will mention a couple of points here.

Basically NASA, as you've heard now several times, has made a lot of reforms and they have cut their budget. Yet, there is a sense of accomplishment, a spirit that the agency is really giving a lot to the American people. We see this practically with a Hubble discovery in the newspapers every few weeks, another fundamental discovery about our universe. We see this with the Galileo probe that entered Jupiter and caught the attention of so many people, the Near-Earth Asteroid Rendezvous launch which happened this year with two missions to Mars later this year. There is a sense that the can-do agency is back performing and making a lot of accomplishments. The Shuttle flights are working regularly, and the Shuttle/Mir rendezvous are thrilling people around the world. There is a real program going on and it has been done in a era of declining budgets, declining budgets now for five straight years.

I think we need to congratulate the Administration and even last year's Congress for the job they did with a very difficult budget situation. NASA was supported, and let us not lose sight of that fact, and I think we appreciate the efforts in this Committee and in the other Committees dealing with the NASA budget.

The fiscal '97 budget, which shows another cut for NASA, does preserve all the programs, and that's important. I think the agency's attempt to keep these programs going and performing well at the same time as cutting the budget shows that the restructuring has worked and the emphasis is on programs and not bureaucracy, and we have a very positive sense of vitality that's going on.

At the same time these budget cuts are beginning to take their toll. The fiscal '97 budget reductions are serious, and fiscal '98 and '99 budget projections are disastrous. The Administration budget that is sent up shows enormous decreases in fiscal '98 and '99. So does the Congressional Budget Resolution passed last year.

Missions will have to be cut. Space science is the particular victim of those budget cuts. If you examine the details within the budget reductions, the Space Station is relatively constant and many of the other programs continue on. Space science, which depends on new starts for its continued vitality, will be cut. Missions we've talked about for years will not happen, and even missions that are now underway will be threatened.

The concern that I represent here is that Space Station has, as it should have and we're pleased that it has, a very good industrial constituency and progress is being made.

Mission to Planet Earth has a very solid constituency in the Administration and in the Senate, and it should have that constituency, and it is well supported.

What is space science's constituency? I think it is the public, this enormous interest that has been shown in space exploration, the enormous interest of what NASA represents to the people, and it is that public that needs to be represented. I hope that we in the Planetary Society as a large-based interest group can represent that interest and make the case that space science not become the victim to priorities between the House and the Senate on Mission to Planet Earth and Space Station.

Thank you.

[The prepared statement of Mr. Friedman follows:]

STATEMENT TO HOUSE COMMITTEE ON SCIENCE SUBCOMMITTEE ON SPACE AND AERONAUTICS

Dr. Louis Friedman
Executive Director, The Planetary Society
April 17, 1996

I am pleased to represent The Planetary Society, the world's largest space interest group with more than 100,000 members. We value the opportunity to present our views to Congress. With no professional or financial ties to the space program, our organization offers a broad public interest perspective for your consideration.

The Planetary Society is deeply concerned about the proposed cuts in the NASA budget which has been submitted to the Congress by the Administration, especially the reductions projected for future years. The proposed 1997 reductions are serious -- the 1998 and 1999 reductions, shown in the attached chart, are disastrous.

NASA's budget has declined every year since 1992. Despite the reductions, the space agency is doing more with less. It is reorganizing its research centers, eliminating duplication and waste, privatizing programs, and reducing personnel. NASA is restoring its image as the "can-do" agency, emphasizing achievements, not bureaucracy.

The **Hubble Space Telescope** results pour in -- fundamental new discoveries are made nearly every month. The shuttle rendezvous with **Mir** thrills people all over the world and effectively merges the human space flight programs of the U.S. and Russia. American astronauts are participating in long-duration flights, accelerating the collection of data to learn how to live and work safely in space.

The **Galileo** spacecraft finally reached Jupiter -- overcoming the dispiriting legacy of failed policies of the 1980s with accomplishments and results in the 1990s. The **Near Earth Asteroid Rendezvous** launch in February began a new era of planetary exploration, in which low-cost, hi-tech robotic probes are used to explore our solar system. Later this year, we'll have two launches to Mars, initiating a decade-long study of the Red Planet. Next year, NASA will launch one mission to the Moon and another mission to Saturn. And we are not alone -- Russia and Japan have launches scheduled to the Mars and Moon in this same time period, and Europe has built the all-important Titan entry probe for our **Cassini** mission to Saturn.

The NASA budget submitted to you recently preserves all these programs. NASA has led a new government approach with their spirited willingness, accepting these cuts, still producing faster and better programs. We support the cost-constrained space station, saving money through international cooperation. We support Mission to Planet Earth, already dramatically scaled-down in cost and scope. And most of all, we support the grand ventures and thrilling results of space science, yielding a wealth of new discoveries serving all humankind.

But the drastic reductions shown in the attached graph for 1998, 1999 and 2000 will effectively put space science out of business. Not only are there no new starts, but space science suffers the largest of the projected NASA decreases. As current missions end, and no new ones start, the U.S. role as a space explorer will die.

Last year the House and Senate passed a long-term budget that calls for an $800 million reduction in spending for NASA in FY 1997 (in real dollars), twice the amount proposed by the Administration. If Congress' budget prevails, the dismantlement of America's space science program will be accelerated, threatening even the ongoing programs and missions such as the **Mars Surveyor** and **New Millennium**.

The Planetary Society believes the out-year spending cuts proposed for NASA do severe harm to our space program. And they undermine our nation's ability to remain the world's leader in advanced technology.

A recent report by the Council on Competitiveness warns that reductions in federal spending are "pushing America into the second rank of industrial countries in terms of overall R&D effort." The report emphasizes that in our growing global economy, R&D is more important than ever.

The council urges government to overhaul its R&D labs, to remove unneeded bureaucracy, eliminate redundancies, improve productivity, and develop new partnerships with academia and private industry. This is exactly what NASA is doing. The space agency is leading the way in operating faster, cheaper, and better. It is thinking smarter and acting smarter to sustain America's competitive system in R&D.

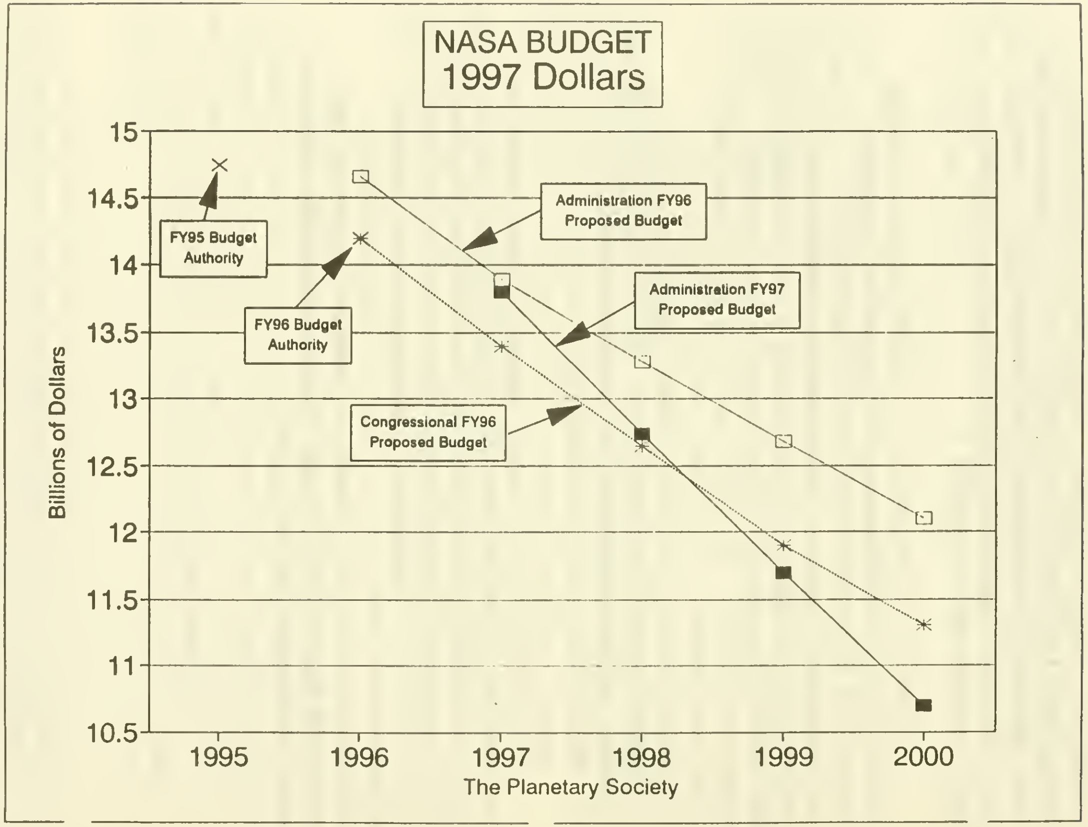
The U.S. space program has three major enterprises: human space flight, space science, and understanding our own planet Earth. These respond to public interest and desire. New knowledge about other worlds, new understanding about our own, and the adventure of seeking that knowledge continue to enthrall the public. Images of Pluto, the discovery of planets elsewhere beyond our solar system, the climate history of Mars and its pertinence to understanding the conditions that make life possible, even those details about the atmospheric conditions on Jupiter -- the public wants this record of accomplishment to continue.

The **Pluto Express** mission should be started -- the recent **Hubble** pictures demonstrated public interest in this faraway planet. Exploring Pluto's methane-ice surface and its moon, Charon, which is draped in water ice, can provide important clues to understanding the formation and evolution of our solar system. There should be a new initiative to search for extra-solar planets, and missions supporting the fundamental human interest in the origin of life and our planet.

An extended **Galileo** mission should also be planned. An extended mission could make repeated flybys of ice-covered Europa and then zoom in on the volcanic Io --two of the most intriguing new worlds discovered in the space age. By extending the **Galileo** mission, it's possible to program a flyby of Europa every six weeks during 1998. The following year, **Galileo** would visit Io and another moon, Callisto. The extension of the **Galileo** mission represents a very cost-effective opportunity. But once again, budget cuts at NASA preclude this undertaking.

Are we about to eat our seed corn, after having so carefully planted it? The Administration and Congressional budgets proposed for 1998 and 1999 will result in cancellation or postponement of programs that the American public wants -- programs that are important investments in science and engineering. On Capitol Hill and in the White House, there is a growing disagreement between the relative budget priority of the space station and Mission to Planet Earth. In the strange way of Washington, we are worried that Congress may be tempted to compromise by curtailing space science. This would be tragic. The American public is supporting a balanced and unified program -- if you unravel that program, you will destroy it.

The Planetary Society urges Congress to support America's space program. The fiscal year 1997 budget should not be reduced below that proposed by the Administration and a message should be sent that supports increased funds for fiscal years 1998 and 1999. NASA needs specific support for existing space station, planetary exploration and Earth science projects. We hope you will ask NASA for new starts for a mission to Pluto and in their "origins" program in the next few years, and to extend the **Galileo** mission to collect valuable data on Europa and Io.



The Planetary Society

Chairman SENSENBRENNER. I'm going to recognize myself first. Last month when we had Mr. Goldin in for the NASA posture hearing, I think that all Members of this Committee on a bipartisan basis were very concerned about the fact that it appears that space science is going to be the principal victim for the downsizing in fiscals '98 and '99.

In the past and at the present time space science has had very strong and unanimous support amongst the Members of this Subcommittee, and that support has not flagged, the support has not waivered, and I think that space science is a part of the core program of NASA, as is manned space, and that when we figure out how to downsize NASA we cannot shuffle around the priorities.

The concern that many Members of this Committee have on Mission to Planet Earth is that the faster, better, cheaper philosophy, which Mr. Goldin has successfully applied to the rest of NASA, is not being applied to Mission to Planet Earth. I think Mission to Planet Earth has a tremendous amount of scientific potential, but it should not be allowed to have cost overruns and eat away at the rest of NASA any more than the Space Station should or the Shuttle should or anything else that NASA has got should.

Now I've got a question of Dr. Sargent. Have you looked at the Administration's budget projections for fiscal '98 and '99 coupled with the apparent change in priority where in 1994 space science was an Administration priority as far as the core program of NASA is concerned, and now it appears to have been replaced by Mission to Planet Earth, and space science thus has become something that is optional which means that it's at the top of the list for budget cuts?

Ms. SARGENT. I have looked at the numbers and my community has looked at the numbers and when I read the Administrator's statements I understood that these numbers are not yet cast in blood. However, I feel that it would be comforting to my community to know, as I have said earlier, that rather than being what you call a victim, we were merely standing up like the rest of NASA and taking proportionate cuts. We feel that we know how to deal with proportionate cuts, but we're extremely concerned at the vision that might be there if the numbers that are bandied about at the moment remain solid.

Chairman SENSENBRENNER. The chart which the staff prepared for last month's hearing with Administrator Goldin had what the Administration defined as the core program on the bottom of the chart and the space science was at the top, and then the line with the OMB recommendations ended up being on the top, which would have meant that had the core programs been protected there would have been very little money, if any, available for space science for fiscal '98 and '99. Has the Advisory Committee looked at those figures and made a recommendation yet?

Ms. SARGENT. No. We have not seen these particular figures. We haven't met since these numbers came out. We would be concerned, very, very deeply concerned if they remain as you have described them to me. I don't know how we would manage in fact to fulfill even our strategic plan.

Chairman SENSENBRENNER. When is your next meeting?

Ms. SARGENT. Our next meeting is actually next week.

Chairman SENSENBRENNER. Will you send us a copy of the recommendations you sent to Mr. Goldin so that it doesn't get lost in the bowels of the NASA bureaucracy?

Ms. SARGENT. I'll be happy to send you the letter that I send, but I send it to Dr. Huntress. I advise Dr. Huntress and not Mr. Goldin.

Chairman SENSENBRENNER. Well, whomever you advise——

Ms. SARGENT. But I certainly will send you a copy.

Chairman SENSENBRENNER. Whomever you advise, we would like to see what the advise is because sometimes bad advice in their eyes is not passed on.

Ms. SARGENT. I would say that at our previous meeting we already saw what I might call the writing on the wall, and we did have a recommendation that said that space science would be prepared to take a proportionate cut, but we hoped that it wouldn't be worse than that.

[The following information was received for the record:]

CALIFORNIA INSTITUTE OF TECHNOLOGY
OWENS VALLEY RADIO OBSERVATORY 105-24

March 15, 1996

Dr. Wesley Huntress
Associate Administrator for Space Science
NASA HQ
300 E. Street SW
Washington, DC 20546-0001

Dear Dr. Huntress,

The Space Science Advisory Committee (SScAC) met at the Jet Propulsion Laboratory in Pasadena, California on March 4, 5, and 6, 1996. This is one the very few occasions, perhaps the only occasion in recent years, when the meeting has taken place outside NASA headquarters. The general sentiment was that the change of venue was refreshing and provided a welcome opportunity to see another face of NASA.

An over-riding concern arising from this SScAC meeting, the threat of a dramatically shrinking Space Science budget, was raised by Dr. Edward Stone, Director of JPL, in his welcoming remarks. Despite this concern, we are very pleased with the current round of new starts and continuing funding that appear to have the approval of Congress. Firm financial commitment to these projects will go a long way to ensuring the successful accomplishment of the goals of the OSS Strategic Plan. We are also delighted that four launches, SOHO, XTE, NEAR and POLAR, took place successfully, despite the Government-mandated furlough. SScAC recognizes that these successes would be laudable in any year. To have achieved them at a time when internal NASA reorganization and external governmental disagreements were causing ongoing turmoil is nothing short of remarkable. We extend our thanks and congratulations to you and all your Staff.

As usual, I have tried to summarize our deliberations under a few headings. These continue below:

REACTIONS TO THE CONGRESSIONAL BUDGET

The strong Congressional support for the NASA Space Science program, as evidenced by the budget agreement for FY 1996, and the continuing broad and enthusiastic press coverage of OSS activities are very reassuring. In particular, the Committee applauds the new starts for SOFIA and TIMED, and the funding for Cassini, SIRTF, and GP-B in the current appropriation. Support such as this is vital to the health of the Space Science Enterprise.

PASADENA, CALIFORNIA 91125, Tel: (818) 395-6622, Fax: (818) 568-9352, E-mail: afs@mmstar.caltech.edu

However, the relatively weak out-year marks for Space Science in the NASA FY 1996 budget submission cause the SScAC grave concern. OSS is currently making steady progress toward the goals set out in its Strategic Plan, and has "road map" activities under way to update the plan for the new millennium. We note that, although the cost, scale, and development time for missions has been significantly reduced, their outstanding core-science programs have been maintained. Nevertheless, the weak out-year marks suggest that NASA's plans for OSS may fall short of our expectations; they may also be inconsistent with the enthusiasm demonstrated by the Congress and the public for a continuing, vigorous, and productive space science program that includes new starts.

o SScAC encourages NASA to explore ways of ensuring a viable long-term OSS budget. Unless the Agency demonstrates sufficient support for space science in the "out years", Congress could rightly conclude that any new starts are simply not viable.

OSS RESTRUCTURING

SSCAC was very pleased by the overall philosophy evident in the presentations of the Board of Directors and the Chairs of their Subcommittees. It is clear from the emphasis placed on inter-disciplinary research, on inter-connecting among the four themes and with other NASA Enterprises, and on outreach to the various constituencies outside NASA, that the Board members are fully aware of the benefits that can accrue from the restructuring of OSS and are committed to ensuring success in the new circumstances.

We welcome the establishment of a subcommittee structure that reflects the new thematic basis of OSS. The re-organization of the Office offers an excellent opportunity to increase communication between the SScAC subcommittees. We believe that this opportunity should be pursued through an "executive committee" comprising the subcommittee chairs and SSCAC chair. This group would interact via telecon on an "as needed" basis, as well as through regular exchange of subcommittee reports/letters. Other means of encouraging a greater degree of interaction should be explored.

The SSCAC endorses the continuation of Management Organization Working Groups (MOWGs). These provide a valuable resource for the Discipline Managers as well as a means of involving the Space Science community in the conduct of OSS programs. We do offer the following specific recommendations:

o The MOWG structure should be redefined once the organization of the RPM Division is in place. This will allow the Discipline Scientists to structure the MOWGS in a coherent sense across all of the Division's activities.

o SScAC encourages cross-cutting MOWGs on topics that transcend any one theme (e.g. data analysis, suborbital program). We consider these particularly important.

o Care should be taken to ensure that the MOWGs function as outlined in the NASA rulebook on advisory committees (i.e. their "primary function is operational, and any advice given is purely incidental"). We do not anticipate any formal relationship between the MOWGs and the SScAC or its subcommittees).

We also strongly advise OSS to dissolve groups that have evolved into standing elements of the SScAC subcommittee structure (e.g., the Science Working Groups (SWGs) associated with the SSES). The functions that those groups were originally intended to serve can, and should, be dealt with by limited-duration task forces that can be convened as required under the aegis of the SScAC or its subcommittees.

Finally, the Committee was very enthusiastic about the formation of the Technology Advisory Panel (TAP). We encourage significant science input to the TAP through a formal connection between the Advanced Technology & Missions Studies and RPM Divisions, as well as by having the chair of the TAP be an ex-officio member of the SSCAC.

o SScAC is very encouraged by the manner in which the new Board of Directors has stepped up to its role.

o We see MOWG's as a continuing vital part of the RPM Division and its interaction with the scientific community and strongly support the concept of cross-disciplinary MOWGs.

TECHNOLOGY DEVELOPMENT

Briefings on a broad range of OSS technology initiatives, including "New Millennium" and "Origins" which are being carried out at JPL and GSFC were very welcome. The science content in New Millennium missions is now clear. We applaud this development and also the improved coordination with OSAT that is providing additional resources in support of these efforts. We recommend that these programs be examined regularly to ensure that developments are undertaken in response to science needs, and that activities be balanced to reflect the full range of research activities in the Strategic Plan. In particular, we suggest that care be taken as the 1997 Strategic Plan is developed to ensure that technology initiatives remain aligned and in balance with the priorities of the evolving Plan.

It is essential that a means be found to transfer these technologies (both spacecraft and sensor/instrumentation) to the science community. We request that OSS present a plan at the next SScAC meeting for achieving this transfer, including means for systematically involving the university community, as well as providing an overview of how these important technology activities are to be blended into the OSS Strategic Plan.

o The SScAC believes that the technology initiatives, as described, have the requisite science components. At our next meeting, we would like to be briefed on the balance of resources between these and other OSS programs.

MISSION OPERATIONS & DATA ANALYSIS (MO&DA) BUDGETS

The Committee recognizes that the OSS budget and the NASA budget, as a whole, are seriously constrained. Within those constraints, OSS has, to date, maintained a balance between research, technology development, new starts, and MO&DA funding across its disciplines. The out-year marks in the FY 1996 budget suggest that it will be increasingly difficult to do so, in spite of improvements such as smaller, more capable craft, and miniaturized instruments that enable more science on these smaller missions.

In this period of declining budgets, funding for extended missions appears to be at considerable risk. New starts are, of course, necessary to maintain the Enterprise, but mission lifetimes should be sufficiently long to ensure optimum scientific return on investment. In cases where the solar cycle is relevant, for example, it would seem ill-advised to terminate important measurement capabilities before the expected solar maximum. Clearly, a balance must be struck by examining all inter-related aspects within OSS. Missions should not be flown without adequate resources for data analysis, and technology development should not be of such magnitude that it prevents funding the very missions that might use the technology.

o SScAC urges that when balancing the budgetary demands across the Enterprise, OSS looks carefully at the relative impacts on science returns. We applaud NASA's efforts to reduce MO costs, and request a briefing at the next meeting to clarify the new central role in this activity for JSC.

NASA INSTITUTES

The SScAC recognizes the various factors that have led the Agency to consider Science Institutes as a mechanism to maintain and improve the quality of the science activities associated with NASA's programs. We believe that the steps taken so far have been reasonable and prudent. However, there remain several critical issues that require sharper definition and associated review. In our opinion, the phased approach described by former Deputy Associate Administrator, Al Diaz, is an appropriate way to proceed. We commend Mr. Diaz and his team for their effort in developing their Plan for Science Institutes.

The Committee is convinced that it is important to define early the criteria by which success of any Institute will be judged. These criteria will clearly differ in detail from one institute to another. Additionally, the SScAC is concerned that the implications of this mode of operation for elements of the overall budget for the Agency in general and Space Science in particular are not well understood. We would like to have a briefing on this issue at the earliest possible time.

We also urge NASA to make every effort to secure input from knowledgeable civil service science staff regarding the operation and nature of the new Institutes, and to do so in a way that does not compromise future career opportunities for those people in the proposed institutes.

o We recommend that the SScAC and its subcommittees be involved in both the establishment of success criteria for space science-related Institutes, and in the assessment of their progress at regular intervals throughout their lifetimes. We await a briefing at the earliest possible time as to the impact of Institutes on the Code S budget.

OTHER ISSUES

SScAC applauds NASA's move to streamline and shorten its funding process, and supports the transfer of grant administration to GSFC. However, we perceive a possibility for discontinuities during the transition that could, if not carefully planned, cause severe disruption in the activities of many Principal Investigators. We urge that everyone involved in this transition be sensitive to potential problems and take whatever steps are necessary to ensure that no investigator's funding is jeopardized because of a procedural issue.

The SScAC congratulates Dr. Berrien Moore and his ad hoc committee for producing an interesting and helpful assessment of the peer review procedure as implemented by Code S. We concur with their findings that the process is fundamentally sound and, in general, with their recommendations.

The Committee also heard presentations from Dr. Alan Dressler on "HST and Beyond," and from Professor Charles Townes on the "EXNPS" Roadmap and Blue Ribbon Panel. Dr. Marc Allen summarized the NRC's FOSS Report. These Reports will help us set the stage for the next OSS Strategic Plan, due in Summer 1997. Dr. Allen also outlined the process now in place by which the NRC Committee for Astronomy & Astrophysics will produce a strategic plan for space astrophysics that can be fed into the OSS 1997 Plan. Each of the OSS Board of Directors and their Subcommittees will initiate appropriate planning activities at their meetings, beginning next month. We believe that we can meet the timetable and guidelines outlined by Dr. Carl Pilcher, OSS Special Assistant for Strategic and International Planning.

Dr. Pilcher's input was very helpful during our discussions of the interim report presented by the task group to redefine OSS Performance Metrics for NASA's "Performance & Plans" document. We expect the final report will be completed in time to be presented at the next NASA Advisory Council meeting on April 23 and 24. The subcommittee tasked with planning implementation of the OSS Education Strategic Plan also presented a satisfactory interim report.

Finally, SScAC is grateful to Drs. J. Gallagher and P. Reiff, who have agreed to share the task of representing SScAC on the Space Utilization Board. The Committee would be happy to create similar liaisons with the proposed workshops on Institutes.

In closing, we would again like to thank you and your staff for the enormous effort exerted to maintain the equilibrium and continuing success of OSS during the last difficult months. We are particularly impressed with the successful launch record throughout this period.

Sincerely,

copy of original, Anneila I Sargent

Anneila I. Sargent
Chair, Space Science Advisory Committee

AIS: buz

Chairman SENSENBRENNER. Thank you very much.

The gentleman from Michigan, Mr. Barcia.

Mr. BARCIA. Thank you, Mr. Chairman.

I don't have much to add to that, but I want to thank you of course, Mr. Chairman, for calling this meeting and for the panel's contributions. I did have a conflict and so I arrived late, but I appreciate your recognizing me.

Chairman SENSENBRENNER. Thank you.

The gentleman from Florida, Dr. Weldon.

Mr. WELDON. I thank the Chairman.

Dr. Ford, I had some questions about POST. How does POST in terms of its costs compare to operating an earth-based observatory in terms of the budget projections that you were talking about?

Mr. FORD. I think our operational cost would be very similar to operating a large observatory like the KET[sic] telescope. We estimate an operations cost of something like $3- to $5 million a year, and that's simply by counting the number of telescope operators, technicians and people that would schedule time on the telescope.

Mr. WELDON. So what you're saying is most of the cost is the actual construction, but then once it exits it can be operated?

Mr. FORD. That is correct. When we estimate the capital cost of installing this we come up with numbers of something like $70- or $75 million, and then we put in money for a five-year operations time. I think the more relevant costs to compare POST to are the missions that we believe it would be similar to, and that would be either Hubble or the NGST, and we see this coming in at something less than a tenth of the cost of Hubble, and it would be I think a comparable figure for the NGST.

Mr. WELDON. You said that the Australians and the Dutch and the Italians would play a role I believe.

Mr. FORD. Yes, they would. We're in a chicken and an egg situation. There is a group of Dutch astronomers that believe that they can get money to get started on this with us to do the pointing and control system and to provide instrumentation, but they cannot get money until this is a funded project in the U.S.

The Italians have a payload, a millimeter telescope that is ready to go. It's just boxed up and could fly immediately.

The Australians for a variety of reasons that are both astronomical and have to do with national interest see much of their future in astronomy and in Antarctica, and they are extremely interested in this, and they have an ongoing program of site testing in Antarctica.

I might add, if I may, that the results they got last winter showed that if you go a mere 100 meters above the ice and get above the inversion layer there in the winter that the seeing is extremely good, and it's better than our models have predicted.

Mr. WELDON. Just a hundred meters?

Mr. FORD. Just a hundred meters, and we would propose in Antarctica to go 8,000 meters. The air is very stable. The reason why the image clarity would be so good is because the air is extremely stable near the center of the circumpolar vortex. It's just extraordinarily well stratified with an absence of turbulence, and that's why we believe that if we can go to 40,000 feet we can get images in the near infrared that will be close to Hubble resolution.

Mr. WELDON. Would this play a role in pursuing the Origins Program?

Mr. FORD. We think it would address two aspects of those. One of the niches where this telescope would do extremely well would be deep imaging at two microns, and the reason for going after origins of galaxies in the near infrared is because of the expansion of the universe and the red shift to the light. So the near infrared is one of the best places to try to see the early universe, and at those wavelengths this telescope, by our very careful calculations using models of the atmospheric transmission and emissivity and putting in the telescope emissivity, would see two and a half to ten times further than the Gemini telescope which is being built at Mauna Kea, and it is being optimized for infrared observations.

The reason we do so much better with a smaller telescope is the atmosphere is far dryer at 40,000 feet than it is at 14,000 feet on top of that mountain, and the resolution of this would be extremely good. If I compare it to Hubble, the resolution would be nearly twice the resolution of the Hubble telescope at the infrared wavelengths. It does beat Hubble at infrared wavelengths, and I should explain the reason for that. I'm not Hubble bashing. You know, I helped fix Hubble and I make my living with Hubble and I'm doing an advanced camera for that telescope.

At near infrared wavelengths the mirrors are warm. That telescope, we hold the interior at about the temperature of this room, 20 degrees Centigrade. I feel a little warmer than that, but it's very close, and the mirrors glow at those wavelengths, at the wavelengths you're trying to observe. On the other hand, the temperatures would be like minus 80 degrees Fahrenheit in the stratosphere, very cold.

Chairman SENSENBRENNER. The gentleman's time has expired.

I would like to thank all of the members of this panel for very interesting testimony, and let me assure each of the members that when we rework the President's budget submission you're going to get a far better shake than you've gotten from OMB for space science.

So thank you again, and we appreciate your testimony.

The fourth panel will be devoted to the subject of Aeronautics. The witnesses are Dr. Jerry Grey of the American Institute of Aeronautics and Astronautics, Colonel Michael S. Francis of the Tactical Technology Office, and Dr. Fred Billig of the Applied Physics Lab at Johns Hopkins University.

Without objection, all of your prepared remarks will be printed in the hearing record in full, and we would ask you to summarize your testimony in five minutes or fewer.

The first witness on this panel will be Dr. Jerry Grey of the American Institute of Aeronautics and Astronautics.

Dr. Grey.

STATEMENT OF JERRY GREY, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

Mr. GREY. Thank you, Mr. Chairman.

The AIAA strongly supports the proposed aeronautical budgets for fiscal '97 and the estimated runout through fiscal 2001. However, these runout estimates do not yet include further planned deficit reduction cuts. When those cuts are made, it is critical that so important an economic driver as aeronautics research and technology not be decimated.

My written statement expresses our strong support also for the research and technology base and also for advanced subsonic technology and urges that the forthcoming cuts in the runout budgets for these programs not be too severe. I'll discuss high-speed research a little later.

But, first, a key question. Why should the government foot the bill for technology validation? Why not let the mature U.S. industries do it? Several reasons.

First, the market. It's projected at just under a trillion dollars over the next two decades, and every dollar invested in U.S. commercial aircraft generates $2.30 in gross domestic product. Keeping this U.S. market share is therefore important to the U.S. taxpayer and not just the aviation industry. And because European governments are willing to make the very large investments needed to reduce technology risk for new aircraft, U.S. industry must compete head to head with government financed manufacturers.

Now in aviation, far more than in other industries, technology advancement is demanded by the customer, forced by competition or driven by public mandates, to improve the environment. An effective technology validation needs a continuity of research efforts that are far beyond and far earlier than the normal scope of corporate research. In the past these efforts have been assumed by the government because they benefit the economic health of the nation.

Now on the high-speed research program there is general agreement that a big market for a high-speed civil transport does indeed exist. Air passenger traffic growth will generate over $10 billion in annual sales of such transports well into the next century. This represents over 100,000 high-value jobs for U.S. industry. Loss of high-speed civil transport leadership to a foreign competitor would also severely impact the market for subsonic transports, which is currently dominated by the U.S., and would lead to a loss of up to 160,000 jobs.

But to realize this market the new high-speed civil transport must also be able to compete with existing aircraft by offering reasonable fare levels. Hence, a go ahead decision by industry will require not only a low-risk of environmental impact, but also sufficiently mature technologies so the aircraft's cost make it marketable.

The proposed increase in the high-speed research budget for fiscal '97 aims at reducing technical risk. Flight validations are a key element in this process.

Another key question. When Phase II of the High-Speed Research Program is complete in 2002 will industry make the multibillion dollar commitment to develop a commercial transport? There is no assurance that they will. That decision will depend on then current market considerations and technical and cost risks. But there is no question that without the High-Speed Research Program U.S. industry will not make such a commitment.

NASA's approach, therefore, appears to make sense. It includes two key elements, annual assessments of success in risk reduction and major participation by U.S. industry. It seems proper to continue this plan until and unless the annual assessments and/or the industry's interest do not support a sound basis for expectation of success.

I would like to conclude with a discussion of hypersonic research which has been pursued in the U.S. for over 50 years. NASA and the Department of Defense have now assembled mutually consistent affordable programs to conduct low-cost flight validation of key technologies. The AIAA's HyTASP Committee has identified flight test data as the key factor in hypersonics.

NASA has proposed a hypersonic X-plane program that complements the Department of Defense's $135 million HyTech effort and also envisions a follow-on Phase II. Dr. Billig I think will probably talk more about that later.

The AIAA's committee strongly supports NASA's proposed hypersonic X-plane program budget of $125 million through fiscal 2001. It is a realistic affordable approach to realizing the goal of operational hypersonic flight for both long-range aircraft and potential space access vehicles.

But as with the high-speed civil transport, there is strong activity overseas in hypersonics, the European Space Agency's $40 million FESTIP effort, France's $85 million PREPHA program, Japan's Spaceplane effort, Russian hypersonic research, which included scramjet flight tests, and even India and Australia have ground tested airbreathing hypersonic engines.

Incidentally, these overseas programs will all be discussed at the AIAA's Seventh International Hypersonics Conference in Norfolk the week of November 7th.

Thank you, Mr. Chairman.

Chairman SENSENBRENNER. Thank you very much.

[The prepared statement of Mr. Grey follows:]

Statement to
Subcommittee on Space and Aeronautics
Committee on Science
United States House of Representatives

On the

Proposed NASA Budget for Aeronautics

By Jerry Grey
Director, Aerospace and Science Policy
American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive, Suite 500
Reston, Virginia 22091

April 17, 1996

Mr. Chairman, Subcommittee members, I am Jerry Grey, Director of Aerospace and Science Policy for the American Institute of Aeronautics and Astronautics (AIAA). The AIAA is a nonprofit professional society of over 35,000 aerospace professionals whose mission is to advance the arts, sciences, and technologies of aerospace. We have testified on the civil aerospace program at hearings held by this and previous Congresses. Our viewpoint is based primarily on the technical considerations that underlie policy decisions concerning the U.S. civil aeronautics and space programs. Because the AIAA represents such a broad spectrum of the aerospace community, it does not reflect the provincial viewpoint of a single constituency, but provides a balanced perspective of the profession as a whole. We welcome this opportunity to comment on the Administration's proposed budget for NASA's aeronautics program.

Introduction

The proposed program in aeronautics for FY 1997 is directed at conducting research and validating selected high-leverage technologies applicable to both subsonic and high-speed regimes. Its ultimate goals are to reduce the development and operating costs of the U.S. aviation industry, to improve world market penetration, and to ensure U.S. leadership in collaborative efforts with other nations. We touch later on the significance of the government's role in achieving these goals.

We strongly support the Administration's proposed increase in aeronautical budgets for FY97 and the continuing efforts reflected in the estimated runout through FY2001. However, these runout estimates do not yet include further planned deficit-reduction cuts. When those cuts are made, it is critical that so important an economic driver as aeronautics research and technology not be decimated.

Research and Technology Base

The growth projected for the Research and Technology Base during the runout period is particularly important. As we have stated in the past, the R&T base is the essential element in opening new opportunities for future aeronautics advances that will contribute to improved performance, enhanced safety, reduced costs, higher reliability, and better operability of U.S.

aviation systems. It contains the seeds of tomorrow's competitiveness for the U.S. aviation industry. The next generation of systems technology programs that will follow the focused efforts in High Speed Research (HSR) and Advanced Subsonic Technology (AST) will come from the R&T base. It is the source of the expertise needed to solve the problems we can't foresee in the near term. This is clearly an area that deserves as much growth as we can afford.

Advanced Subsonic Technology

We also applaud the Administration's vigorous support of the AST program, and urge that the forthcoming cuts in the NASA runout budgets for this key group of focused technologies not be too severe. This program gives appropriate attention to assuring a cleaner, quieter environment, reducing delays in the national airspace system, and sustaining and enhancing the near-term competitiveness of U.S. aviation products in an ever more competitive global market environment.

Aeronautical Technology Validation: A Proper Role for Government

But first, a key question: Why should the government foot the bill for technology validation in either the AST or the HSR focused-technology programs? Why not let the mature U.S. aviation industry do it? Several reasons. First, the global commercial aviation market is projected at just under a trillion dollars over the next two decades, and it is estimated that every dollar invested in U.S. commercial aircraft generates $2.30 in gross domestic product. Halting the erosion of U.S. market share is therefore increasingly important to the U.S. taxpayer, not just the aviation industry.

The mechanism used in Europe is instructive. Unlike their American competitors, European manufacturers of civil aircraft and engines often receive government-sponsored loans to subsidize product development. Repayment is contingent on a predetermined level of the product's commercial success. A recent General Accounting Office report stated that as of 1990 the French, German, and British governments had invested $13.5 billion in direct support of Airbus Industrie products. By August of 1993 the amount repaid was only $3.5 billion.

The European governments, it seems, have decided that the very large investments needed to reducing technology risk for new aircraft require government support. U.S. industry, in contrast, must compete head-to-head with its European counterparts, and its product development costs for new aircraft must be completely underwritten by industry, often resulting in "peak negative cash flows that can exceed the value of the company."

In any industry, competitiveness is determined by market requirements and readiness, financial viability and resource capabilities, system capacity availability, and technology readiness. Decisions related to technology readiness are relatively straightforward when the technology is well understood, development has been completed, the payoffs are clear, and the risks are low. But in new airplane programs, competition pushes the state-of-the-art, shortens available development scheduling, and requires establishing goals that strain credibility and involve considerable technical, cost, and schedule risk. And in aviation, far more than in other industries, technology advancement is demanded by the customer, forced by competition, or driven by public mandates to improve the environment.

An important consideration that bears heavily on the government's role is that intense competition requires commercial aircraft programs to be based on guaranteed performance and a committed market price without a causal relationship to costs. Hence the tradeoff between the value added by specific technology applications vs. their cost and risk must be understood prior to making product commitments. This requires technology validation, and effective technology validation demands a continuity of research efforts long before the technology application is defined. Such efforts are far beyond the normal scope of corporate research and technology development. In the past they have been assumed by the government, whenever such investments were deemed to benefit the economic health of the nation.

High Speed Research (HSR)

It is hoped that completion of the Phase II HSR effort by NASA in FY2002 will provide sufficient risk-reduction assurance for industry to invest in the development of a commercially viable HSCT. The key factor in that decision, of course, is not technology but marketability; that is, acceptably low technology risk is a necessary but not sufficient condition for commercial HSCT development.

There is general agreement that a sizable potential market does indeed exist. The AIAA's Aeronautics Subcommittee has estimated that projected air passenger traffic growth, especially in the burgeoning Pacific rim market, is likely to generate over $10 billion (500 - 1,000 supersonic transport aircraft) in annual sales of HSCTs well into the next century. This represents over 100,000 high-value jobs for U.S. industry. A loss of HSCT leadership to a foreign competitor would severely impact the market for subsonic transports currently dominated by the U.S. and lead to a loss of up to 160,000 jobs, with a major impact on U.S. balance of payments.

But to make this market a viable one, the new HSCT cannot rely solely on its ability to offer shorter trip times. It must also be able to compete effectively with existing aircraft by generating a profit for its developer at reasonable fare levels; e.g., 18 to 20 cents per seat mile (the Concorde, for example, costs about 80 cents; the 747 only 14 cents). Hence a "go-ahead" decision by industry will require not only a low risk of environmental impact, which was the primary goal of the recently completed first phase of NASA's HSR effort, but also sufficiently mature technology to provide a reasonable expectation that the aircraft's costs will allow it to be marketable.

The 8.8% proposed increase in the HSR budget for FY97 is devoted to what we believe are the key critical areas of HSCT technology: reducing aircraft structural weight and enabling the development of a dependable, high-performance propulsion system that can meet the expected environmental requirements. However, a number of secondary technology issues associated with this year's successful High Speed Civil Transport (HSCT) Technology Concept Definition will also continue to require attention during the remainder of the decade; e.g., aerodynamics, fuel-tank sealing, flight-deck automation and human factors, continued reduction in both chemical and acoustic environmental effects, operational considerations, etc. Flight validations are a key element in this process.

Another key question: When Phase II of the HSR program is complete in 2002, will its achievements in reducing risk and in validating economic viability be sufficient for industry to make the multi-billion-dollar commitment required to develop a commercial transport?

There is no assurance that industry will indeed step up to the commitment needed to develop a commercial HSCT once the HSR program is completed. That decision, as we've noted earlier, will depend on then-current market considerations and technical/cost risks. But there is no question that without the HSR program, the U.S. aviation industry will not make such a commitment. The approach NASA has taken in the HSR program therefore appears to make sense. The agency has laid out a reasonable plan which includes two key elements: annual assessments of success in risk reduction via both research and technology validation, and major participation by U.S. industry. In consonance with our earlier discussion about the government's role in aeronautical technology validation, therefore, it seems proper to continue this plan until and unless the annual assessments (and/or the industry's interest) do not support a sound basis for expectation of success.

Hypersonic Research and Technology

Hypersonic research has been pursued in the U.S. for over 50 years. It is central to the full exploration and expansion of the flight envelope. Following termination of the National Aerospace Plane program several years ago, there was some uncertainty in formulating a national strategy for hypersonics that would encompass both civil and military needs. That uncertainty now appears to have been resolved, and both NASA and the DoD have assembled mutually consistent *affordable* programs to expand research efforts and, most important, to conduct low-cost flight validation of key technologies. The AIAA's newly created HyTASP Committee has identified the need for flight-test data as the key factor in the effective pursuit of viable hypersonic flight technology.

The first step toward DoD's goal of eventually developing hypersonic vehicles able to reach time-critical targets has been implemented by a $135-million Hypersonic Technology Program (HyTech) to complete free-jet tests of a hydrocarbon-fueled supersonic-combustion ramjet (scramjet) by FY2002. It is effectively complemented by NASA's proposed hypersonic X-plane program, to conduct wind-tunnel testing at Langley at Mach 5-10 and subsequently fly a small-scale, unpiloted experimental hydrogen-fueled airplane in the Mach 5 to 10 range starting in 1998.

NASA's proposed hypersonic X-plane program also envisions a follow-on Phase-II effort whose goal would be an experimental vehicle able to test over the range from takeoff to Mach 10, using turboramjet and dual-mode scramjet propulsion systems. Additional technologies and propulsion systems may also be tested in the future. The AIAA's HyTASP Committee strongly supports the proposed hypersonic X-plane program budget of $125 million through FY2001. It represents a realistic, affordable approach to addressing the key issues facing the long-sought goal of operational hypersonic flight for both long-range hypersonic aircraft applications and potential space access vehicles.

As in the HSCT, there is strong activity overseas in pursuing hypersonic flight technology. The European Space Agency's $40-million Future European Space Transportation Investigation Program (FESTIP) includes consideration of airbreathing as well as rocket engines for space launchers. France's $85-million PREPHA program has focused primarily on hydrogen-fueled scramjets since 1992; its future plans include flight testing. Japan's Spaceplane program includes ramjet and scramjet research; hypersonic tests of a quarter-scale turbojet-ramjet engine (ATREX) were conducted in 1994 and 1995. Russian hypersonic engine research has been underway for some time; they conducted scramjet flight tests at Mach 3.5 - 5.5 in 1991-92. Even India and Australia have ground-tested airbreathing hypersonic engines as long ago as 1992. Full discussions of these overseas programs will be presented at the AIAA's Seventh International Hypersonics Conference in Norfolk, VA the week of November 17th, 1996.

Although the economic returns from operational hypersonic flight are significantly further downstream than those of the HSCT, the rationale cited earlier for government involvement is nevertheless still valid: "effective technology validation demands a continuity of research efforts long before the technology application is defined." NASA's proposed hypersonic X-plane program, in concert with the complementary DoD efforts in hypersonic technology, represent the long-sought practical, affordable approach to fulfilling that role in hypersonics.

Thank you, Mr. Chairman, for the opportunity to present our views on this most important aspect of this nation's economic future. I will be pleased to answer any questions you or the Subcommittee members might have.

BIOGRAPHY BRIEF FOR DR. JERRY GREY, DIRECTOR, AEROSPACE AND SCIENCE POLICY AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

Dr. Jerry Grey received his Bachelor's degree in Mechanical Engineering and his Master's in Engineering Physics from Cornell University; his PhD in Aeronautics and Mathematics from the California Institute of Technology.

His early career included stints as full-time Instructor of Thermodynamics at Cornell, engine development engineer at Fairchild, Senior Engineer at Marquardt, and hypersonic aerodynamicist at the GALCIT 5-inch hypersonic wind tunnel. He was a professor in Princeton University's Department of Aerospace and Mechanical Sciences for 17 years, where he taught courses in fluid and aerothermodynamics, jet and rocket propulsion, and nuclear powerplants and served as Director of the Nuclear Propulsion Research Laboratory. He was President of the Greyrad Corporation from 1959 to 1971, Adjunct Professor of Environmental Science at Long Island University from 1976 to 1982, and Publisher of Aerospace America from 1982 to 1987. He is now Director of Aerospace and Science Policy for the American Institute of Aeronautics and Astronautics (AIAA), consultant to a number of government and commercial organizations, and Visiting Professor of Mechanical and Aerospace Engineering at Princeton University.

Dr. Grey is the author of twenty books and over 300 technical papers in the fields of aeronautics, space technology, space transportation, fluid dynamics, aerospace policy, solar and nuclear energy, spacecraft and aircraft propulsion, power generation and conversion, plasma diagnostics, instrumentation, and the applications of technology. He has served as consultant to the U.S. Congress (as Chairman of the Office of Technology Assessment's Solar Advisory Panel and several space advisory panels), the United Nations (as Deputy Secretary-General of the Second UN Conference on the Exploration and Peaceful Uses of Outer Space in 1982), NASA (as a member of the NASA Advisory Council), the Department of Transportation (as a member of the Commercial Space Transportation Advisory Committee), the Department of Energy (as a member of the Secretary of Energy Advisory Board), and the U.S. Air Force, as well as over thirty industrial organizations and laboratories. He was Vice-President, Publications of the AIAA, Chairman of the Coordinating Committee on Energy of the American Association of Engineering Societies, a Director of the Scientists Institute for Public Information, Vice-President of the International Academy of Astronautics, and President of the International Astronautical Federation.

Dr. Grey is listed in Who's Who in America and about twenty other honorary publications. His publications include "Beachheads in Space" (Macmillan) and his widely acclaimed book on the Space Shuttle, "Enterprise" (William Morrow). He has received national awards from the Aviation/Space Writers Association and the American Astronautical Society.

Chairman SENSENBRENNER. The next witness is Colonel Michael Francis of the Tactical Technology Office of the Defense Advanced Research Projects Agency.

Colonel Francis.

STATEMENT OF COLONEL MICHAEL FRANCIS, TACTICAL TECHNOLOGY OFFICE, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Colonel FRANCIS. Thank you, Mr. Chairman, and thank you for the opportunity to share my views on aeronautics research and technology and also for the invitation to comment on the investment strategy for National Aeronautics and Space Administration programs in the outyears.

In my statement I have indicated my background and my connection with NASA over the years, and I won't repeat that. I have been involved for the better part of my 20-plus-year career in programs which have either interfaced with NASA directly or for which I was involved on the periphery. So I have a strong connection with NASA over those years. Over that time I have come to appreciate NASA's unique charter, a mandate to pioneer and to discover with a focus on the future in both aeronautics and space.

Let me observe that in just seven short years manned, heavier-than-air-flight will have reached its century mark. The advances and spinoffs that have occurred since that magnificent accomplishment by the Wright brothers in 1903 have been many and varied, and to many of us today those are routine events. The observation of manned flight in our lives signifies a high level of maturity for the aeronautics technologies, especially when one looks at the common routine occurrences of transcontinental and global travel.

However, I believe that the perception that aeronautics is a mature technology area is premature. While the impression may be there that the field may be stagnated, I believe that there are still many interesting opportunities for discovery and invention that go beyond the bounds of current programs. I will attempt to address a few of those in my remarks.

In your invitation you specifically asked me to comment on hypersonic research as it relates to NASA, and I agree with my colleague, Dr. Grey, that we long ago have penetrated the boundaries in that broad range of flight conditions, but have done very little real flying there. This is one of those environments that still poses significant barriers to efficient and affordable operation, and that word "affordable" is one we're very conscious of in DOD as well for both manned and unmanned systems.

The ability to travel routinely at the very high speeds associated with hypersonic flight would offer tremendous advantages for global outreach, effectively shrinking the planet in a way that can benefit both our civil and defense industries. Although we tend to segregate aeronautics and space as separate disciplinary endeavors, the successful conquest of the hypersonic arena is as important to the realization of affordable access to space as it is to long-range atmospheric transport. Launch and re-entry systems must cope with the hypersonic flight environment over a substantial portion of their operational envelopes.

The funding history of hypersonics research has been a roller coaster ride initially primed by events that suggested either a pressing need, often it was defense related, or an imminent technological breakthrough. On each occasion this was followed by a substantial reduction in support when the results were less than spectacular.

The most recent example of this was the implementation of the National AeroSpace Plane Program of the late 1980s and early 1990s time frame. The NASP vision was a noble one, but its realization was forestalled for the lack of a few key technology breakthroughs in critical performance areas. The most significant of these was a lack of a credible and capable and efficient propulsion scheme which was both operational and economically sound.

In moving toward the NASP vision we invested broadly in all elements necessary to develop the complete hypersonic vehicle, later focusing more limited resources on the known key technological deficiencies. Accompanying the demise of these hypersonic initiatives has been the loss of critical corporate memory as many researchers exited the dying field never to return.

We should not give up the quest for high-speed flight, but neither should we employ the tactic of throwing money broadly at the problem either. Rather, we should carefully direct the hypersonics investment to those tough problems which represent the real showstoppers and then only when credible solutions are proposed.

Only after these solutions are made available or at least realistically in sight should we begin to consider the development of complex and potentially expensive flight systems. And for the case of hypersonics this applies to the range of hypersonic speeds that we're talking about since the solution for very Mach numbers is different from those in the Mach 8 regime, for example. Because of the need for continuity in the research force all efforts should be made to create a stable program environment.

But aeronautics today encompasses more than just the hypersonics issue. There are several other opportunities which are timely to pursue under this broad research umbrella. Included among these are the continuing quest for more efficient and effective means of propulsion in all regimes. This includes identification and adaptation of new fuels and other energy sources for sustaining atmospheric flight.

An area with perhaps the greatest promise for a payoff in the aeronautics is the marriage of rapidly-developing information technology arena with evolving air vehicle technology well beyond the levels being pursued today. The positive implications of this merger relate to a variety of applications ranging from air traffic control efficiency and effectiveness to a dramatically improved ability to deal with adverse weather conditions, influencing the way we control and operate air vehicle systems. It may even serve to change the fundamental paradigm of flight as we know it.

I am currently involved in the study of a possible uninhabited air vehicle system for defense applications. We are learning that there may be significant value to removing the human operator from the volume and weight- constrained cockpit environment and placing him instead at the center of information. This attempt to provide improved situation awareness in a physically less stressing environment affords a capability for improved decision-making in situations which may often have lethal implications. The cost benefits of achieving this capability appear to be substantial as well.

The NASA programs provide a sizable fraction of the nation's investment in its future in air and space. NASA's charter to pioneer has never been more appropriate than in today's fiscally constrained environment in times which seem to promote the short-term perspective.

Therefore, I advocate an approach which allows investment in a spectrum of programs to co-exist ranging from evolutionary development efforts to the more high-risk, high-payoff projects, the latter having the potential to really reshape the future in dramatic fashion. I also believe that more time and energy should go into identifying and characterizing the tough technology problems that are critical to achieving those goals.

Chairman SENSENBRENNER. The time has expired.

[The prepared statement of Colonel Francis follows:]

NOT FOR PUBLICATION
UNTIL RELEASED BY THE
HOUSE COMMITTEE ON SCIENCE

STATEMENT BY

COLONEL MICHAEL FRANCIS, USAF
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

to the

HOUSE COMMITTEE ON SCIENCE
SUBCOMMITTEE ON SPACE AND AERONAUTICS

APRIL 17, 1996

NOT FOR PUBLICATION
UNTIL RELEASED BY THE
HOUSE COMMITTEE ON SCIENCE

Thank you for the opportunity to share my views on aeronautics research and technology, and for your invitation to comment on the related national investment strategy for future National Aeronautics and Space Administration (NASA) programs.

Although I have spent my career as an active duty military officer, I have devoted a great portion of it to aeronautics research for Department of Defense (DoD) applications. During that time I have had numerous opportunities to observe and interact with NASA. Over the last five years, I have served as the DoD program manager for the X-31 Enhanced Fighter Maneuverability (EFM) Program - an international effort with several U.S. agency partners, including NASA. This highly successful project, which set several technical and programmatic records for X-planes, owes much of its success to the NASA collaboration. Earlier in my career, I served on NASA's Advisory Committee on Aeronautics, initiated and conducted cooperative programs in fundamental aerodynamics research with NASA, and maintained a close and constant liaison with the NASA aeronautics community. Over that time, I have come to appreciate NASA's unique charter - a mandate to *pioneer* and *discover*, with a focus on the future in aeronautics and space.

In just seven short years, manned, heavier-than-air flight will have reached the century mark. The advances and spinoffs that have occurred since that magnificent accomplishment by the Wright brothers in 1903 have been many and varied. To many of us today, the routine (and often intrusive) observation of manned flight in our lives signifies a high level of maturity for the aeronautics technologies. Transcontinental and global travel are common daily events, and many believe that few discoveries and/or inventions remain in this area. However, I believe this to be an inaccurate perception. While there may be a impression of stagnation in the area of aeronautics - the configuration of the aircraft seems to vary little from one generation to the next - I believe there are still many opportunities for discovery and invention to be exploited. I will attempt to address a few of these in my remarks.

In your invitation, you specifically asked me to comment on hypersonic research as it relates to NASA. Although we long ago penetrated the boundaries of that broad range of flight conditions referred to as hypersonic flight, this environment is one which still poses significant barriers to efficient and affordable operation of both manned and unmanned systems. The ability to travel routinely at the very high speeds associated with the hypersonic regime would offer tremendous advantages for global outreach - effectively shrinking the planet in a way that can benefit both our civil and defense interests. Although we tend to segregate aeronautics and space as separate disciplinary endeavors, the successful conquest of the hypersonic arena is as important to the realization of affordable access to space as it is to long-range atmospheric transport. Launch and reentry systems must cope with the hypersonic flight environment over a substantial portion of their operations.

The funding history of hypersonics research has been a "roller coaster ride," initially primed by events that suggested either a pressing need (often defense-related) or imminent technological breakthrough. On each occasion, this was followed by a substantial reduction in support when the results were less than spectacular. The most recent example of this was the implementation of the National AeroSpace Plane (NASP) Program of the late 1980s - early 1990s timeframe. The NASP vision was a noble one, but its realization was forestalled for the lack of a few key technology breakthroughs in critical performance areas. The most significant of these was the lack of a credible, capable and efficient propulsion scheme which was both operationally and economically sound. In moving toward the NASP vision, we invested broadly in all elements necessary to develop a complete hypersonic vehicle, later focusing more limited resources on the known key technological deficiencies. Accompanying the demise of these hypersonic initiatives has been the loss of critical "corporate memory" as many researchers exit the dying field, never to return.

We should not give up this quest for higher-speed flight, but neither should we employ the tactic of "throwing money" broadly at the problem. Rather we should carefully direct the hypersonics investment to those tough problems which represent the real showstoppers, and then only when credible solutions are proposed. Only after these solutions are made available or, at least, are realistically in sight, should we begin to consider the development of complex and potentially expensive flight systems. Because of the need for continuity in the research force, all efforts should be made to create a stable program environment.

But aeronautics today encompasses more than just the hypersonics issue. There are several other "opportunities" which it is timely to pursue under this broad research umbrella. Included among these are the continuing quest for more efficient and effective means of propulsion, in all speed regimes. This includes the identification and adaptation of new fuels and other energy sources for sustaining atmospheric flight.

An area with perhaps the greatest promise for a payoff in aeronautics is the marriage of rapidly-developing information technology with evolving air vehicle technology, well beyond the levels being pursued today. The positive implications of this merger relate to a variety of applications ranging from air traffic control efficiency and effectiveness, to a dramatically improved ability to deal with adverse weather conditions, influencing the way we control and operate air vehicle systems. It may even serve to change the fundamental paradigm of flight as we know it.

I am currently involved in the study of possible uninhabited air vehicle systems for defense applications. We are learning that there may be significant value to removing the human operator from the volume- and weight-constrained cockpit environment and placing him instead at the "center of information." This attempt to provide improved situation awareness in a physically less stressing environment affords a capability for improved decision making in situations which may often have lethal implications. The cost benefits of achieving this capability appear to be substantial as well - ranging from lower air vehicle acquisition costs to possibly dramatic reductions in related operations and support requirements. From a safety perspective, the advantages may be even greater. While we recognize the unique value of the human operator in certain situations, we also know that automated systems are less prone to the routine mistakes to which the human occasionally falls prey. The key element underpinning this idea is to capture the best attributes of both manned and unmanned systems - understanding where the digital computer provides the best solution and identifying those circumstances where the human computer is most ideally suited.

The NASA programs provide a sizable fraction of the nation's investment in its future in air and space. NASA's charter to *pioneer* has never been more appropriate than in today's fiscally constrained environment, in times which seem to promote the short term perspective. Therefore, one approach could be to allow a spectrum of programs to co-exist, ranging from evolutionary development efforts to high risk-high payoff projects, the latter having the potential to shape the future in dramatic fashion. I also believe that more time and energy should go into identifying and characterizing the tough technology problems that are critical to achieving those goals, and then focusing the investment on them. At the same time, NASA should maintain a constant vigilance to identify and monitor those promising, new "opportunities" which exhibit the potential for revolutionary change. In doing so, it is important that a degree of programmatic "agility" be retained to enable a timely redirection of resources toward these issues.

I thank you for the opportunity to present my views, and welcome your questions.

Chairman SENSENBRENNER. And finally Dr. Fred Billig of the applied Physics Lab at Johns Hopkins University.

STATEMENT OF FRED BILLIG, APPLIED PHYSICS LAB, JOHNS HOPKINS UNIVERSITY

Mr. BILLIG. Thank you, Mr. Chairman and Committee Members for the opportunity to address issues related to hypersonic programs in the 1997 NASA authorization.

My written remarks discuss in detail my critique of the NASA 1997 programs and my recommendations for more aggressive development of low-cost space access vehicles. I choose to use these few minutes of testimony to address the broader issue of a vision which can exploit our technology base in hypersonics.

I believe that in one of the hearing rooms there is a quote from Proverbs XXIX, "Where there is no vision the people perish." In a more positive tone this could be restated "Where there is vision the people flourish."

I believe that visionary leadership is mandatory to rekindle the support and enthusiasm of the public, which in turn I believe can turn around this awful trend in the demise of the NASA budget.

In my written remarks I have suggested that perhaps a candidate for a national leadership position could embrace this visionary four-point manifesto, namely:

—I believe that man is destined to explore space.

—The United States will lead this effort.

—Our first objective will be exploration of Mars and safe return to planet Earth no later than the year 2020.

—The first phase of this ambitious program will be to augment the space station platform for assembly of the Mars explorer.

Hypersonics is the technology that can make this vision a reality, and the rocket based combined cycle engine is the propulsion concept that makes this possible. It is not a new concept. Ground tests of the engines operating at low speeds and the conceptual designs of orbital access vehicles were completed more than 30 years ago. The technology for mid and high-speed ram-scramjet propulsion system, developed in part under the NASP program, is sufficiently mature to proceed with the design of candidate configurations. Ground tests of the propulsion path could start in a few months and flight tests of an RBCC, that acronym for this cycle, could begin in three years. This is truly an aeronautical answer to the space access program.

The most economical space access program will require two vehicles, one man-rated with a payload capability of perhaps 5,000 pounds, and the other a non-man-rated space truck with a payload capability of about 50,000 pounds to space station. RBCC propulsion is the system of choice for both of these vehicles.

I do not wish to imply that there is no activity in NASA directed towards the possible development of an RBCC space access vehicle. Indeed, there are laudable efforts that have been initiated under the Highly Reusable Space Transportation and the Advanced Space Transportation Programs which should ultimately lead to the selection of RBCC as an alternative to advanced rocket systems.

What I do wish to convey is that RBCC should compete with, and not follow, the development of rocket powered reusable launch systems. Moreover with the vision of Mars exploration as a realizable goal, I doubt that the public will provide the necessary support.

Let me just comment on a couple of the statements made prior to my statement, namely, you can look at applications as a metric for the different types of propulsion systems that have been brought before your attention over many years. Those applications are missiles, hypersonic aircraft and what I was focusing on, space access vehicles.

In a very simplistic way often one would like to believe that there could be a common platform and a common vehicle. They have distinct genera, and one of the problems that we have is that we believe that one program is going to solve the problems of programs devoted towards the other attention. This is one of my concerns about the 1997 budget. The hypersonics program initiation, which is a $125 million item in the budget, is primarily for the use of hypersonic crews and not space access.

Thank you very much.

[The prepared statement of Mr. Billig follows:]

Proposed Statement of Frederick S. Billig to the Subcommittee on Space and Aeronautics

17 April 1996

I have been asked by your Chairman to address issues relating to hypersonic programs covered in the 1997 NASA Authorization. I thank the Committee and Chairman for this opportunity. Hypersonic refers to speeds greater than Mach 5, five times the speed of sound or about 3400 mph. My comments will be primarily directed toward hypersonic applications which employ airbreathing propulsion. My remarks will emphasize technology issues, but I will also address the management and marketing of the programs.

Applications provides a useful framework for my comments. The three primary applications of hypersonic airbreathing are missiles, cruise aircraft and space access vehicles. Whereas, missiles may well be the first application of hypersonic airbreathers, due to the urgent national needs for defense against time critical targets, this application is in the province of the DoD, NASA cooperation should be, and is, encouraged but this should not be a major NASA thrust.

For the hypersonic cruise aircraft application, the 1997 NASA budget has a commitment for the initiation of Phase I, of a two phase program, that, at the conclusion of Phase II, would provide a prototype of a Mach 10 hypersonic airplane in 2008. Phase I is a five year $125 M ($25 M 1997) program to culminate with four flight tests of a small scale ram-scramjet over the Mach number range of 5-10. Some of the reasons this program should be supported are:

(1) It is an affordable program intended to validate design methodologies which should provide an audit trail from the computer, through ground testing to flight verification.

(2) It should resolve numerous technical issues and thereby reduce risk to an acceptable level which would permit the development of a military hypersonic cruise aircraft.

(3) It will provide continuity in the NASA aeronautical research effort and thereby enable the agency to establish and maintain competence in hypersonic flight research.

The vehicle design for this hypersonic airbreathing application should not be marketed as a hypersonic test bed that can readily be adopted to test concepts of missiles or space vehicles. The genera of conceptual designs for these applications are uniquely different. Emphasis in the conceptual design in Phase I needs to address the accommodation of the tandem propulsion cycle that must be integrated to provide operation at Mach 0 to 5. The absence of the use of test facilities at NASA Ames in the current test plan for Phase I also is of some concern. For high speed testing the HYPULSE facility is indicated; the 16 in. shock tunnel at NASA Ames has more capability. Moreover, the 100 MW, DCAF at NASA Ames should be a key facility for development of high Mach combustors. Funding to maintain these key national assets should be provided in the 1997 NASA budget.

The role of airbreathing propulsion in the third application, space access, is my principal concern regarding NASA activities in 1997. Note that I do not cite particular line items in the budget but, rather the total activity in access to space. This includes the X33, the X34, HRST (Highly, Reusable Space Transportation), RLV (Reusable Launch Vehicle), etc. programs. The following quotation will serve as introduction.

"Chemical rockets have now advanced to the stage where the hard-fought battle for a few extra points in specific impulse become more and more expensive and show smaller relative returns. The impressive strides in American rocket development since Sputnik have now put us ahead of the opposition for the moment. Present and planned chemical rocket programs will provide the Earth-to-orbit propulsion requirements, as well as lower-stage requirements for direct flight modes, for our space missions into the mid-1970's. However, the costs of developing these chemical rockets system are enormous, and the projected costs of launching space missions escalate each year. This is causing rocket engineers and their government sponsors and planning groups to search very hard for (a) practical schemes for recovery and reuse of launching systems and (b) alternate, more economical propulsion system." ("Hypersonic Airbreathing Propulsion" by W. H. Avery and G. L. Dugger, Astronautics and Aeronautics, June 1964.)

Thirty-two years have passed and this search needs to be expeditiously completed. The advocacy for recoverable, reusable rocket powered systems is established and the NASA 1997 budget reflects adequate support in these endeavors. Support "for alternate, more economical propulsion systems" needs to be enhanced.

The most attractive airbreathing cycle is the air-augmented rocket, which more recently has been named the Rocket Based Combined Cycle (RBCC) engine. The strongest justification for the use of RBCC for space transportation is the inherent low cost. By integrating the rocket into the flow path of the dual-mode ram-scramjet, several fundamental design and operational problems are greatly simplified. Variable geometry is minimized, rotating machinery is unnecessary, and overall performance is greatly in excess of pure rockets. The net result is that small, relatively low cost, and readily serviceable vehicles can be designed to meet the payload requirements.

Single Stage To Orbit (SSTO) designs of RBCC devices for both horizontal and vertical launch are feasible, however it could turn out that the lowest cost system will be two stage (TSTO) wherein the first stage is RBCC and the second stage is a rocket. Transonic thrust-drag pinch dictates that the second stage must be in the silhouette of the first stage or comprise the forebody in a tandem arrangement. The aerodynamic, L/D efficiency of either SSTO or TSTO vehicles is relatively unimportant whereas high packaging efficiency is mandatory; therefore, waverider configurations probably are not attractive.

The "landing gear" (takeoff and/or landing) is a relatively heavy structure comprising about 3-4% of the vehicle weight. In a SSTO horizontal take-off and landing vehicle, significant weight saving will accrue if an adjunct system such as a trolley or rail launch assist is used for takeoff. For an airbreathing SSTO system the weight saving would be about 70%. Launch assist has the additional benefit of a reduction of the on-board propellant required to accelerate, thereby decreasing the size and cost of the air vehicle. In principle, the take off velocity could be significantly higher than on a runway thereby not only saving additional propellant, but also reducing the wing area. Many factors would limit the maximum speed at take off, including the maximum longitudinal acceleration for a given track length and the maximum dynamic pressure. An inclined track relieves the latter but increases the "propulsion" requirement for the launch assist system. For TSTO systems, the weight saving for the first stage would be smaller, and probably would not be justified, considering the loss of flexibility of operations.

Aerobrake-parachute system for the second stage of a TSTO or a SSTO rocket may be preferable to either a horizontal landing gear or a powered vertical landing system (e.g., DC-X). However, to minimize cost, recovery, either land or sea, must avoid the requirement of on-site or close-proximity assets.

The linch-pin of the entire low cost system is the air breathing portion of the combined cycle engine. Very innovative design features must be embraced to provide the required performance in a relatively low cost reliable design. An example would be a new approach to active cooling. The trajectory of the airbreather must be suppressed to enable the capture of sufficient air and to maintain pressure in the combustor adequate to support combustion. Typically, this results in a flight path with dynamic pressures of about 2 atm from about Mach 2 to Mach 15. Heat transfer rates to leading edges and the internal ducts are severe. Vehicle designs such as NASP have contemplated the use of highly cooled thin walled structures with pressurized hydrogen as the coolant. Considering the hazards of foreign particle damage and catastrophic failure modes, the use of a more benign secondary fluid such as water needs to be examined. Weight penalties can be mitigated by generating water in flight in an internal reactor. Hydrogen with stored oxygen, or preferably captured air, are the reactants and the heat of combustion is added to the propulsive stream to increase the propulsive efficiency. Appurtenant uses of the generated coolants are for non reactive transpiration, leak seals, etc.

To date, the studies by NASA e.g., "Access to Space Study" have not had access to contemporary designs of high performance, light weight RBCC engine designs. As a consequence these studies have not revealed the true potential of the system. In particular, the concept for the integration of the rocket into the airbreathing flow path and the operation and performance of the engine over the speed range Mach 0-3 has not heretofore been adequately addressed. To redress this shortcoming, a new engine concept was introduced in Reference 3. Performance of the engine at low speeds has been determined and the information has been forwarded to NASA to incorporate into revised vehicle designs. Preliminary studies at The Johns Hopkins University Applied Physics Laboratory have shown that the RBCC yields a lower dry weight vehicle than an turbine based combined cycle (TBCC) engine for a specified payload. Conversely, for the same size vehicle and a slightly higher dry weight, the payload can be more than doubled.

In my judgment the most economical space access program will result in two vehicles, one man-rated with a payload capability of about 5,000 lbm; the other a non-man-rated "space truck" with a payload capability of about 50,000 lbm to space station. RBCC propulsion systems are well suited for both of these vehicles.

With adequate funding flight testing of a RBCC vehicle could commence in three years. The conceptual design; however, is unique and cannot evolve from that of a rocket powered reusable launch vehicle. The program could be the joint undertaking of the NASA Lewis Research Center and the NASA Marshall Space Flight center with participation from industry and academia. It is recommended that specific language could be included in the 1997 NASA Authorization to direct initiation of this project.

Finally, I believe that the current trend of reducing support for the space program can only be reversed by visionary leadership which will engender the support of the public. A suggested manifesto for a candidate for high office is:

- I believe that man is destined to explore space.
- The United States will lead this effort.
- Our first objective will be exploration of Mars and safe return to planet Earth no later than the year 2020.
- The first phase of this ambitious program will be to augment the space station platform for assembly of the Mars explorer.

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Frederick S. Billig

In the spring of 1996, Dr. Billig will be retiring as the Associate Supervisor and Chief Scientist of the Aeronautics Department of The Johns Hopkins University Applied Physics Laboratory (JHU/APL), Laurel, Maryland. He was responsible for high-speed propulsion programs sponsored by the U.S. Air Force and NASA and was the program manager of the National Aerospace Plane (NASP) Project at JHU/APL. In 1989, was the recipient of the NASP Pioneer Award. In 1991, Dr. Billig received the lifetime achievement award from JHU/APL "in recognition of his pioneering, analytical, and experimental contributions to the understanding and development of supersonic combustion ramjet engines, his leadership on behalf of national and international professional societies, and his decades of dedication to the education and mentoring of current and future aerospace engineers." Dr. Billig's research has focused on airbreathing propulsion, external burning, and supersonic combustion. He was awarded the Dryden Research Lectureship by the American Institute of Aeronautics and Astronautics (AIAA) in 1991 for his lifetime of research. He is a Fellow, past Vice President, and Director of the AIAA, having served on numerous technical committees as technical chairman of the 16th Joint Propulsion Conference and a lecturer for several AIAA short courses.

Dr. Billig is a member of the Combustion Institute, where he received the Silver Medal in 1968. In 1966, he was named a Distinguished Young Scientist by The Maryland Academy of Science. More recently in 1992, he was awarded the M. M. Bondaruck award as a pioneer of scramjet research by the Soviet Academy of Sciences and USSR Aviation Sport Federation. He was elected to the National Academy of Engineering in 1995.

He is past member of the U.S. Air Force Scientific Advisory Board and the NASA Space Systems Technical Advisory Committee. He is also the Vice President and U.S. National Representative to the International Society for AirBreathing Engines (ISOABE) and serves as editor of the Technical Proceedings. He has several patents and is co-inventor of the supersonic combustion ramjet. He has published over 140 technical papers and lectured extensively throughout the world.

Dr. Billig is a resident of New Market, Maryland.

Chairman SENSENBRENNER. Thank you.

The gentleman from Florida, Dr. Weldon.

Mr. WELDON. I thank the gentleman.

Before I get into my questions I just want to state something for the record for the benefit of not only this panel but the previous panel. I feel very strongly that every Member on both sides of the aisle on this Committee would like to invest more money in a multitude of different areas of research and science. It's just that with entitlement programs and deficit costs we're going to spend $260 billion paying interest on the debt in 1996 alone.

If some of the tough decisions that we're being forced to make now had really been made 10 years ago we would have more money for a lot of these important science programs. I feel very strongly that what many of you, and particularly the last panel, are trying to do is very, very important in terms of the United States remaining first in technology and research.

To get to a question, I have a question for Dr. Grey. You stated, or I think it was in your written testimony that the hypersonic flight is valid despite the fact that economic returns are significantly downstream. I was interested in that, and the question that I have for you is should NASA be making its investment in research that has the potential to yield technology that will be available now for industry to capitalize on, or should NASA be trying to bring technologies that are just totally outside the reach of industry more into the present, get it out of the future into the present?

Mr. GREY. Well again the answer has to be a little of this and a little of that. You can't focus on either/or. What you do is you put your emphasis where your budget allows you to put an emphasis. If you look at the high-speed research program at NASA you'll find that it's roughly in the current budget about eight times as high as the hypersonic research budget, which seems appropriate, because the high-speed civil transport is investing money that industry otherwise would not invest, but will return to the taxpayers some sort of revenues within the next 20 or 30 years.

If you look at hypersonic research, yes, that's something NASA certainly should do. The question is how much effort do we put into very long-term research as compared to research that can have near-term payoff. If your interest is in budget deficit reduction I think the answer is clear. You do both, but you put your emphasis on the one that reduces the budget soonest, and I think that NASA's proposed budget for '97 does that in a proper context.

Mr. WELDON. Thank you.

Colonel Francis, you stated in your testimony that the demise of the NASP program was due to technological deficiencies. Do you feel that there were some program management problems in that as well playing a role in its demise?

Colonel FRANCIS. I wasn't that close to the NASP program programmatically. So really it's unfair for me to comment on that side of it. I know that the major reason it didn't carry forth is that the ability to get sustained flight at those speeds from an airbreathing propulsion system wasn't here and still isn't here at the high end of Mach number range, and that was the major showstopper. I'm not sure that all the programmatic corrections, whatever they might have been, could have solved that problem.

I think that those are ideas that need to be pursued and money provided when solutions to those problems surface. You need to sustain the investment in areas to keep people thinking of the problem and working on analytical and computational solutions and even experimental solutions at an appropriate scale and not building flight hardware before its time.

Mr. WELDON. Are we taking full advantage of international cooperation in the area of hypersonic research?

Colonel FRANCIS. This is a two-edged sword, international cooperation, having been associated with an international program. There is a very real advantage to working with someone who brings both ideas, resources and a willingness to work together to the table.

Since much of the aeronautics arena flows directly into the commercial world, of course in those areas one is concerned about the competitive environment. So one crafts the kind of program we're talking about carefully. Since we don't have the answers in hypersonics there is a case to be made for international cooperation on the fundamental issues, how one treats it further downstream, as the technology matures is a different matter.

Chairman SENSENBRENNER. The gentleman's time has expired.

The gentleman from Michigan, Mr. Barcia.

Mr. BARCIA. Thank you very much, Mr. Chairman.

Last summer Congressman Weldon and I had the privilege of joining other Members of the Science Committee to travel to the West Coast to see some of the latest technology, particularly aeronautics, and one of the things that impressed me the most was the utilization of the GPS or global positioning system in helping to land large commercial aircraft and how that is being utilized in the private sector.

I just was wondering what your thoughts are in terms of the possibilities for the global positioning system being more perhaps utilized throughout the private sector and would it, in your opinion, be helpful in this NASP program? I know that Dave already asked a question on that that I intended to ask and you answered that pretty well.

But could you comment just on your views on global position systems and other technology that might result from basic science research and our support at the federal level in terms of how that will continue to hopefully be utilized in the private sector. I think on your earlier point that we need to do more to enlighten the public as to the benefits that can result from some of this research and development effort.

Would you care to comment on that.

Mr. GREY. Let me start anyway. The global positioning system and also the comparable Russian system are written in as the eventual navigation system for all the world's airlines. So it is in the plan to use satellite navigation as the fundamental navigation system. Tests have already shown that you can land and take off airplanes totally using the global navigation system and no other backups, and several air operators are already licensed to do so. So this is not future. This is today.

Now the question is how will we implement such a system effectively. The FAA is currently wrestling with that problem, and hopefully they're coming up with the right answer. But the Administration has just a week or so ago come up with a policy which says that selective availability of the global navigation system will terminate within four to ten years and it will then be available to all operators to use it. However, current methods of obtaining accurate use of this system are in operation today.

So I would say it's a system that is already in growth. I believe there is $10 billion of revenue planned by the year 2000 in this field, and in aviation it certainly is going to be one of the key elements of the future.

Mr. BARCIA. One of the things that I've been amazed at, Dr. Grey, being an outdoorsman and an avid hunter, is that as I scan some of the products in the hunting stores and stores that are across the country that sell devices for hunting the GPS is now available to hikers, campers, hunters and anyone who enjoys the outdoors to help them get their bearings back. While I have not purchased one, I was amazed at the cost because I think some of the units available now are in the range of $100 or so.

So I think the public certainly appreciates that example of how research that is funded through NASA and through the Federal Government can actually be utilized in a fashion that will be available to almost every citizen. So thank you.

Colonel FRANCIS. Let me just add that GPS I view as but one off-board information source that might be taken advantage of for the aircraft and the aircraft operator. It provides him with information on where he is. But there are other sources that may be cultivated, and I alluded to several of those in my comments. That is sort of precisely what we're trying to do with our efforts in understanding the advantages of uninhabited aircraft, and that word is carefully chosen because the human operator is very much in the airplane but just not physically.

Whether you exploit information for that purpose or use it to simply improve crew productivity or improve safety it has implications for all of those. So the merger of information technology, GPS being the first we have seen realized, and the aircraft is something that is coming along because of the information revolution.

Mr. BILLIG. May I also add to the GPS utilization in a different way, and I would also like to respond to the NASP issue that was raised before because I am in quite a bit of disagreement with the previous answer.

First of all, with respect to GPS, there is an immediate change to what has happened in hypersonics technology. Where missile technology was what was brought along first in hypersonics, and that began more than 35 years ago, and the biggest problem in putting those systems into utilization, which are really needed right now, was in the targeting and navigation. Those systems now can be put on board a missile and it makes the whole system practical and is the basis in fact for one of the renewed optimisms in going ahead with that kind of program.

With respect to NASP, I need to speak in terms of the technology people with respect to what happened in NASP. My laboratory conducted nearly all of the research efforts and development efforts in the high-speed side of the propulsion path development. They were carried out with respect to inlets and Mach numbers at 10, 14, 16.5 and in terms of combuster development up to Mach numbers greater than 12.5, and in other supporting technologies.

At the end of the NASP program we had met all of the performance estimates that were initially calculated by myself and others back in late 1959 when NASP was first proposed and we never came short on any of those technology projections.

The technical problems with NASP were brought about in a sense by a marketing and management error at the very beginning where we tried to make NASP all things for all people. It was to have both a tremendous capability as what I would call a hypersonic cruiser as well as space access, and it was to be manned from the outset. The program could not go ahead from the marketing perspective unless the first flight was a space access vehicle, and indeed we had a program that would have cost two or three times what the budgetary allowances were.

Had that program addressed space access with a minimal vehicle to demonstrate the technical capabilities of engines operating over this broad Mach number range it would have been a successful program and it would have flown in the time it was stated to do so.

The recommendations that I've made today with respect to rocket-based combined cycle engines as a competitor, a competitor now with a very low cost new technology rocket I think is a fair competition and it's not one that is limited by the technology. The technology, we've been working on this scram-jet/ram-jet concept now for 40 years. It has been 25 years ago that I first had an engine operating on the ground up to Mach numbers above Mach 7 with remarkably good performance. Thank you.

Chairman SENSENBRENNER. The gentleman's time has expired.

The gentleman from Texas, Mr. Hall.

Mr. HALL. Mr. Chairman, since I've had other things on my schedule I've not heard their testimony and I do not know what questions have been asked, but if I might have your indulgence to send them questions if I need to.

Chairman SENSENBRENNER. Without objection.

That concludes questions of Panel No. 4. I would like to thank all of you for coming and for your very useful testimony.

Again, there might be a few written questions from Mr. Hall and others, and I would appreciate a prompt response so that we can get those answers in the hearing record when it is published.

So these witnesses are excused.

The next panel is on Human Exploration and Development of Space.

The witnesses are, first, Mr. Wilbur Trafton, Associate Administrator of the Office of Space Flight at NASA, second, Mr. Kent Black, the Chief Executive Officer of the United Space Alliance, third, Vice Admiral Robert F. Dunn of the Aerospace Safety and Advisory Panel and, fourth, Mr. Dan Tam, the Space Station Business Manager of NASA in Houston.

All of your prepared testimony will be printed in the record in its entirety, and I would like to first recognize Mr. Trafton.

STATEMENT OF WILBUR C. TRAFTON, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT AT NASA

Mr. TRAFTON. Good afternoon, Mr. Chairman. It's a pleasure to be here.

If I could, I would like to have my written statement placed in the record, and then I'll read a short summary.

Chairman SENSENBRENNER. Without objection.

Mr. TRAFTON. Mr. Chairman and Members of the Subcommittee, I'm pleased to appear before the Subcommittee today for the first time as the Associate Administrator for the Office of Space Flight to report on the performance of the International Space Station Program.

I have asked Mr. Tam to speak on the business aspect of the assembly development activities in his oral statement.

I'm very proud of the talented and innovative people at NASA and our contractor team. We are reinventing the way we do business and the Space Station Program is a superb example of what is being accomplished.

The American people's long captivation with space travel and space stations assures that our progress to make the International Space Station a reality will receive much attention. As such, NASA's performance for the foreseeable future will be judged to a great extent on our ability to deliver.

For me assuring that we meet Space Station commitments means completing necessary safety and performance upgrades on the Shuttle and sustaining Shuttle operations throughout the Space Station's designed life and meeting our customers' needs.

To effectively achieve this goal Johnson Space Center has been lead responsibility for these programs and will have full management responsibility and authority and, thus, full accountability for the Shuttle and Space Station Programs.

This has been a significant year of accomplishment for the Space Station. At the Boeing facility in Huntsville, Alabama the first node of the Space Station is being outfitted for its flight in December of next year.

In addition, the U.S. laboratory, node two and the U.S. habitation module have either been completed or are near completion of the initial stages of manufacturing. Over 83,000 pounds of flight hardware have been manufactured. This significant amount of hardware signals that we have moved into the manufacturing and development phase of the Space Station Program.

Let me give a few examples of the important work being accomplished by our program team. As I have stated, Node 1 is in the mechanical installation phase being prepared for assembly and checkout. All structural welding is complete. Node 1 has been our most challenging element to date. It has been late on several internal milestones and as recently as last week had a concern arise in the pressure testing of the node structural test article. I'm happy to say that we performed a partial pressure test on the structural test article over the weekend and reaffirmed that the design is adequate. We are now moving forward to full pressure testing maintaining our schedule.

McDonnell-Douglas Aerospace has manufactured approximately 12,000 pounds of flight hardware. Included in this are such items as a truss structure, a mobile transporter, and components of the active thermal control system.

At Rocketdyne over 20,000 pounds of flight hardware have been manufactured, including such elements as solar arrays, an active thermal control system, and photovoltaic modules. Rocketdyne recently met a major flight hardware milestone with the delivery of their first flight mass canister. The mass canister is a vital component of the Space Station's solar array assembly.

While we are making progress, we are still having to make program adjustments to meet the needs of our international partners and at the same time maintain our own national goals.

Negotiations are being conducted with Russia to reach agreement on activities that will allow Russia to extend the on-orbit lifetime of Mir and provide additional research opportunities on board Mir for the United States. In the meantime the Russians are doing an excellent job on the Phase I contract and on development of the functional cargo block.

Our other partners also continue to make progress. The Canadian Space Agency is progressing toward delivery of the flight hardware for the Space Station Remote Manipulator System.

The European Space Agency has recently signed its industrial contract for the design and development of the Columbus Orbital Facility, their lab. In fact, I was just briefed this morning. It's an $850 million contract, the largest single contract that ESA has ever signed.

The Japanese Space Agency continues to make excellent progress on all of their elements, and the Italian Space Agency is continuing to maintain schedule on the Mini Pressurized Logistics Module.

The International Space Station rivals the complexity of any development program this agency or this government has ever undertaken, and we face in the coming months the largest amount of scheduled workload for any single year of the program. It will continue to be a challenge step of the way. We believe we have the tools and the talent we need to get the job done.

We are proud that the Congress and the American people have entrusted us with this venture, the human development and exploration of space. We know that the ultimate benefit will be to all people, increasing the level of human productivity working safely and effectively in space and inspiring future generations.

Thank you for the opportunity to appear before you today, and of course I welcome questions when appropriate, sir.

Chairman SENSENBRENNER. Thank you, Mr. Trafton.

[The prepared statement of Mr. Trafton follows:]

Hold For Release Until
Presented by Witness

Statement of

Wilbur C. Trafton
Associate Administrator
Office of Space Flight
National Aeronautics and Space Administration

before the

Subcommittee on Space and Aeronautics
Committee on Science
U.S. House of Representatives

April 17, 1996

Mr. Chairman and Members of the Subcommittee:

In meeting the challenge to achieve stability, balance, and relevance, we are reinventing the way we do business at NASA. The Space Station program is a superb example of what is being accomplished. We have restructured the program to maximize available resources to provide balanced support for all NASA programs and still make the International Space Station feasible.

First, let me state that the Space Station Program is currently being managed within budget. We have consolidated layered and fragmented management and multiple contractors into a single Space Station Program Office with a single Prime contractor, Boeing Defense and Space Group. From that organizational base we've adapted, developed, and employed management tools that have sustained our progress. These tools support a variety of management functions giving a range and depth of performance results, status and trends at given points in the program. We have delivered hardware as we promised. In doing so we've met challenges. These challenges have improved our manufacturing processes and quality control and given us new confidence and foresight to carry through the engineering development ahead. Internationally we have synergized a diversity of interests and ways of doing business into a template for future government and commercial ventures in the human exploration and development of space.

Now, let me provide a level of detail and examples of the areas I've introduced; financial status, management processes, technical development and international affairs:

NASA made a commitment to this nation in 1993 to deliver a completed space station on-orbit in June 2002. We said we would do that for $17.4 billion, within an annual funding cap of $2.1 billion. Let me state for the record that in spite of anything you may have heard or read, we continue to stand by that commitment. As you know, this is the first time in the long history of the Space Station that we have had stable funding. It is for that reason that we have been able to achieve the successes we have seen over the last three years. Nevertheless, the $2.1 billion funding cap has created a challenge for station managers. The natural profile of a development program is not a straight line. For that reason, we have had to utilize carryover funding from year to year in order to accommodate the peak program spending which is happening right now. We have been successful in doing this, though it has not been an easy task.

From a management perspective, the International Space Station program has undergone some well-publicized scrutiny within the past few months, and there have been headlines reporting that the program is over cost and behind schedule. The NASA Independent Annual Review (IAR) Team and the General Accounting Office (GAO) cited negative trends identified by the program's performance measurement system. This is data which station managers use on a regular basis to identify areas which require special attention. Both the IAR Team and the GAO would tell you that the problems they identified are well known to program management. To accurately gauge and assess program performance, we have instituted a rigorous, program-wide Performance Measurement System. Using this system, cost and schedule baselines are calculated and reviewed against key cost, schedule, and technical metrics. Cost and schedule data, compiled by Work Breakdown Structure, are vigilantly monitored for any variances against our baseline plan. The Performance Measurement System is working as designed. It has become an effective tool in helping us to determine exactly where to focus management attention. It is equally important to understand how to interpret and apply the data yielded by this tool. The performance measurement system is one tool we use which shows cost and schedule variances against a contract baseline at a specific point in time. It does not take into account contractor reserves or budgeted program reserves which can be used to take corrective action. NASA has adequate reserves in 1996 to cover known problem areas. Due to aggressive budget controls, the program has $3 billion in reserves available. The schedule baseline has built-in margin for flexibility as we plan for each flight. The key point here is that we may use some of our reserves to maintain our schedule flexibility, but we are in no danger of broaching our $2.1 billion annual cap.

Are there technical challenges to the program? Of course there are. We have made no secret of the difficulties we experienced with welding and tooling the node structural test article late in 1994. We overcame those problems, and we are resolving subsequent schedule impacts to the other flight hardware being manufactured in the same facility. This has been an area where we have placed management emphasis in order to successfully implement a recovery plan which allows us to maintain program schedule.

Space Station assembly activities have progressed well during the past year. It has been a significant year of accomplishment. At the Boeing facility at Huntsville, Alabama, the first Node of the Space Station is being outfitted for its flight in December 1997, only 20 months from now. In addition, the U.S. Laboratory and an additional Node have completed the initial stages of manufacturing while the U.S. Habitation Module has nearly completed this stage. At this point we are increasing the role of Kennedy Space Center (KSC) by assigning the flow managers for the early U.S. elements to enhance the prelaunch planning and ultimate launch processing activities.

In light of the challenges, over 83,000 pounds of flight hardware have been manufactured. We have a long way to go before launch, but 83,000 pounds is a significant amount of hardware and signals, to a great extent, that we have moved out of the design phase and into the manufacturing or development phase of the Space Station program. I would like to illustrate what this progress means for the program by giving a few examples of the important work being accomplished by our three major contractors, which we refer to as Product Groups.

At Boeing-Huntsville (Product Group 3) in Alabama, the first Node is in the mechanical installation being prepared for assembly and checkout. All structural welding is complete. While Node 1 has been late on several internal milestones, recovery plans are in place to meet the 1997 launch date for its designated flight (2A).

Node 2 is being used as the structural qualification test article. All structural welding and mechanical installation has been completed. The Node is in a proof-pressure test facility at the Marshall Space Flight Center in Huntsville, Alabama and is being prepared for the first of the three planned structural tests that will be completed this year.

We are on schedule to begin assembly and checkout operations for the U.S. Laboratory in August 1996. Structural welding is complete. The mechanical installation phase that is underway will include the two hatches and common berthing mechanism rings, trunnion hardware, window hardware, and longeron caps that will be drilled to support external debris shield brackets. When completed late this spring, the module will be put through a proof-pressure test to prove the module's structural integrity.

In addition, the Life Support Equipment and Avionics Systems of the U.S. Lab have been produced and packaged in designated System Racks. The life support equipment and Avionics system are being qualified by major subcontractors including Allied Signal, Hamilton Standard, Loral, Harris, Grumman, Teledyne Brown, Arde, Lockheed, Orbital Science, and ILC Technology. In 1997, the Lab will undergo the extensive, integrated test and checkout activity to qualify all systems prior to shipment to Kennedy Space Center in the summer of 1998.

The Habitation Module is being used as the structural qualification test article to qualify the Lab and Hab primary structure. The Hab Module has completed all welding operations in the Boeing facility at Marshall Space Flight Center and is now in the machining process. This process will provide flat precise surfaces for installation of hatch and berthing mechanism seals, window features for the Module's two windows, and features for the trunnion mounts.

It is not only the heavy pressurized modules that are coming together and being prepared for ultimate delivery to the Kennedy Space Center for processing, testing and integration with the Space Shuttle. We also have made strong progress in hardware development at the other two Product Groups.

McDonnell Douglas Aerospace (Product Group 1) has manufactured over 11,500 pounds of Space Station flight hardware. Included in this are such things as ISS truss structure, the Mobile Transporter, and components of the active thermal control, guidance and navigation control, the command and tracking, and command and data handling systems.

At Rocketdyne (Product Group 2), over 20,500 pounds have been manufactured including such elements as the solar arrays, active thermal control system, photovoltaic modules, batteries, and pump flow control assemblies. Rocketdyne recently met a major flight hardware milestone with the delivery of the first flight mast canister by AEC-Able to Lockheed Martin Missiles and Space (LMMS). The second flight mast canister is in acceptance testing and will be delivered to

Lockheed this month. The mast canister is a vital component of the Space Station's solar array assembly.

In parallel with development and construction of the International Space Station, NASA is moving ahead with development of a suite of research facilities that will equip the Space Station as a Science and Engineering research laboratory. The pool of principle investigators in the Life and Microgravity Sciences who will use these facilities has grown to almost 700 investigators and will reach over 900 by the time the Space Station is completed in 2002. Utilization planning is in full-gear to maximize scientific return once the Space Station begins to function as a laboratory.

We have adjusted the program prudently to meet the needs of our International Partners while continuing to meet our own national goals. A clear strategic perspective allowed us to flexibly execute our plans, maintaining stability by holding firm on our own commitments. Negotiations are being conducted with Russia to reach agreement on activities that will allow Russia to extend the on-orbit lifetime of Mir and provide additional research opportunities onboard Mir for the United States. An added benefit is that what we learn through these new opportunities will enable us to reduce on-orbit assembly risks when we begin to construct the International Space Station. We continue to produce results that exceed our expectations through the Shuttle–Mir program and, as the National Research Council has stated--NASA has made enormous progress and we are on course to meet our objectives. Our other partners continue to make progress. The Canadian Space Agency (CSA) is progressing toward the delivery of the flight hardware for the Space Station Remote Manipulator System (SSRMS). The European Space Agency (ESA) has recently signed it's industrial contract for the design and development of the Columbus Orbital Facility (COF) and the Japanese Space Agency (NASDA) continues to make excellent progress on all of their elements. The Italian Space Agency (ASI) is continuing to maintain schedule on the Mini Pressurized Logistics Module (MPLM).

Not only have we faced the normal, unforeseen events that crop up in a development program of this size and complexity, but we have had to hold together an intricate web of international relationships. Since we made our commitment during the 1993 redesign, we have absorbed additional hardware content into the program. We have adapted to the changing political environments of our international partners. Although there have been substantial program changes, we have, and will continue to carry out the current baseline within the available funding profile.

Will we continue to have unforeseen challenges? Yes. Will there continue to be program risk? Of course. This is a risky business. That is why we have tools like the performance measurement system. That is why we maintain a budgeted program reserve. It's all part of managing the program, and that is precisely what we are doing and will continue to do. There is no easy way to make this pioneering endeavor happen. It will continue to be a challenge every step of the way. But we believe we have the tools and the talent we need to get the job done.

It is important to understand that the International Space Station rivals the complexity of any development program the Agency or this Government has ever undertaken. Therefore, it is natural to have some areas where we incur difficulties. But the Space Station program continues to meet each challenge. We face in the coming months the largest amount of scheduled work for any single year of the program. This is a breakthrough year for the Space Station. We believe we have the right processes and expertise in place to effectively manage the program.

We are proud that the Congress and the American people have entrusted us with this venture--the human development and exploration of space. We know that the ultimate benefit will be to all people, increasing the level of human productivity working safely and effectively in space, and inspiring future generations.

Thank you for the opportunity to appear before you today and now I welcome any questions you might have.

Chairman SENSENBRENNER. Second will be Mr. Kent Black, Chief Executive Officer of the United Space Alliance.

Mr. Black.

STATEMENT OF KENT BLACK, CHIEF EXECUTIVE OFFICER, UNITED SPACE ALLIANCE

Mr. BLACK. Mr. Chairman and Members of the Subcommittee, I'm pleased to have this opportunity to discuss the current status of negotiations between the United Space Alliance or USA and NASA on the Space Flight Operations Contract.

Mr. Chairman, I know that you and the Committee are aware that United Space Alliance, which is a joint venture of Lockheed-Martin and Rockwell, was formed last August in response to NASA's decision to transfer its Space Shuttle operations to a single prime contractor. Last November NASA Administrator Dan Goldin announced that the agency would pursue a non-competitive agreement with USA to become that single prime contractor.

I'm pleased to report that USA and NASA have made significant progress. On April the 12th, last Friday, USA and NASA signed two agreements novating the Space Operations Contract at JSC previously held by Rockwell, and the Shuttle Processing Contract at KSC previously held by Lockheed-Martin to the USA. USA immediately subcontracted performance of the work back to the two parent companies. The content of these two contracts will remain unchanged and USA will charge no fees in this transaction.

Novating these contracts, which represent about 80 percent of the operations effort being done on the Shuttle Program, establishes USA as the single prime contractor for launch processing and the mission operations work.

Novation enables us to implement an early start in transitioning operations and employees into USA more efficiently and more cost effectively. We, in fact, intend to begin transferring employees into USA by the 1st of June of this year.

USA and NASA teams are also jointly developing the procurement products needed to implement the Space Flight Operations Contract. Our innovative approach involves the joint development of the required cost baseline with the DCAA and NASA and joint development of the management plan and the statement of work with NASA. Following these steps, contract terms, and fees will be negotiated in the traditional arms-length process.

We expect to complete the definitized contract by September and start the SFOC Phase I on October 1st of this year. At that point the previously novated SPC and SOC, or Space Operations Contracts, will be terminated. Following the Phase I other support and flight elements subcontracts will be added based on USA's demonstrated readiness and by mutual agreement.

I was also asked to comment on the possible divestiture of Rockwell's aerospace and defense operations. As some of you are aware, in January of this year I retired from Rockwell, and therefore it would be inappropriate for me to comment on whatever their plans may be. But if the current press reports are accurate and reports on the divestiture of the complete aerospace and defense segments, and assuming that this segment is sold to a major responsible aerospace contractor, I would expect minimal impact to United Space Alliance.

USA understands the importance in the first priority of safe operations of the Shuttle. The management and the communications processes and the independent reviews that were incorporated following the Challenger accident to ensure safety will continue, with the exception of those layers of oversight that are jointly deemed redundant.

We intend to facilitate the continued involvement of NASA personnel in all of our processes and databases to allow them to achieve insight into the status of the program while we at USA at the same time implement our own necessary checks and balances.

In addition, USA and NASA have mutually agreed to establish incentive structures that emphasize safety as our first priority. We expect to have major penalties for an accident, award fees that are based at least in part on anomaly or quality escape trends, incentives tied to on-time missions, and USA will share in overrun of underrun of costs. The overarching goals for all us in order of priority are to fly safely, meet the manifest, and reduce costs. Safety, not savings, will remain our highest priority.

We will continue to work with you and the Members of the Committee to ensure that our job is completed correctly and we'll keep you informed of our progress.

That concludes my oral statement.

Chairman SENSENBRENNER. Thank you, Mr. Black.

[The prepared statement of Mr. Black follows:]

Written Testimony

of

Kent M. Black

Chief Executive Officer

United Space Alliance

presented to

Subcommittee on Space and Aeronautics

Committee on Science

U.S. House of Representatives

April 15, 1996

Mr. Chairman and Members of the Subcommittee:

I appreciate the opportunity to submit this written testimony concerning the current status of negotiations between the United Space Alliance and NASA on the Space Flight Operations Contract.

USA and NASA have made significant progress in negotiations for this contract. On April 12, 1996, USA and NASA signed agreements for two major contracts designating USA as the prime contractor for launch processing and mission operations work for NASA's Space Shuttle fleet.

With novation of these contracts, USA has assumed responsibility for the Shuttle Processing Contract (SPC), NAS10-10900, previously held by Lockheed Martin Space Operations Company at NASA's Kennedy Space Center and for the Space Operations Contract (SOC), NAS9-18000, previously conducted by Rockwell Space Operations Company in support of the Johnson Space Center (JSC) in Houston. Responsibility for all contract obligations on the SPC and the SOC have transferred from Lockheed Martin and Rockwell to United Space Alliance. The content of the two contracts will remain intact until the Space Flight Operations Contract (SFOC) is authorized on October 1, 1996. These two contracts were novated to USA for performance prior to SFOC authority to proceed.

This assumption of responsibility allows USA to implement "early start" initiatives. We have already begun the process of transitioning billing, accounting and other business systems (including the payroll system) into USA's operations. Orientation and rebadging of SOC and SPC employees into USA will begin on about June 1, 1996 and we plan to have our modified business systems operational about June 1, 1996.

The SFOC will be implemented in two phases. Phase I is the consolidation of all Shuttle Operations Contracts already held by the United Space Alliance parent companies of Rockwell International and Lockheed Martin under the management of United Space Alliance. This phase also includes as subcontracts work performed by Rockwell's Space Systems Division for Shuttle Systems and Payload Cargo Engineering, Shuttle Orbiter Production, Operations and Sustaining Engineering and Orbiter Logistics.

United Space Alliance will continue the work presently being performed on these contracts, with incentives for improving efficiency and reducing cost. Employees working under the existing contracts will continue as subcontractors to United Space Alliance or will experience a badge change and become United Space Alliance employees.

Phase II will focus on the orderly transition of other major support contracts to United Space Alliance as its new management structure matures and as its demonstrated performance during Phase I merits the assumption of increased responsibilities. Phase II work content also includes subcontracts for production of the remaining Shuttle flight hardware and software elements.

We are working with NASA to develop the required procurement products to implement the Space Flight Operations Contract. NASA, DCAA and USA technical, procurement, and management representatives are working together to develop the required cost baseline, management plan, and statement of work. We expect to complete the definitized contract by September and initiate SFOC Phase I on October 1, 1996. At that point the previously novated SOC and SPC contracts will be terminated.

After the start of the SFOC contract, the Space Shuttle Program will remain NASA managed but NASA's role will shift from one of program "oversight" to "insight." Oversight is defined as day-to-day management of work while "insight" allows NASA audit and surveillance of work to a level of detail that enables independent assessment of anomalies should such occur. To enable NASA to have insight into program activities, we are implementing state-of-the-art management information systems to track quality, schedule and cost data. In addition, USA managers will work alongside their NASA counterparts on a daily basis as we transition various roles and responsibilities.

Our overall goals for the SFOC program are to fly safely, meet the manifest, and achieve cost reductions. We are working with NASA to assign a highly qualified team experienced in all technical and management areas of manned space flight operations to achieve these goals. We plan to negotiate contract incentives that will ensure that safety remains the first priority.

We and our NASA customer are incorporating a highly skilled NASA/contractor work force into our team. This same work force has accumulated significant experience over the past 10 years in performing the operations required by the SFOC.

USA was designed to incorporate all elements of the Space Shuttle under one management team so as to reduce duplicative efforts across companies and Centers. As a result of the horizontal integration across the entire scope of SFOC, and a continuous improvement emphasis, new cost reduction options (resulting from potential consolidations and restructuring) will be identified.

We agree with our NASA customer that the new Space Flight Operations Contract will continue the success of America's Space Shuttle program and meet the manifest for assembling the International Space Station. We fully understand the complex responsibilities of managing this program. And we look forward to continuing in working with you and NASA in maintaining the achievement of our space program.

Chairman SENSENBRENNER. The third witness is Vice Admiral Robert F. Dunn.

Admiral Dunn.

STATEMENT OF VICE ADMIRAL ROBERT F. DUNN, AEROSPACE SAFETY & ADVISORY PANEL

Admiral DUNN. Good afternoon, Mr. Chairman and Members of the Committee.

In the interest of time with your permission I'll submit my statement for the record.

Chairman SENSENBRENNER. Without objection.

Admiral DUNN. Let me just say that the Aerospace Safety Advisory Panel of which I am a member treats very seriously its responsibility to monitor safety throughout NASA and its contractors particularly with regard to human flight, both aircraft and space.

Also in the thrust of previous statements to this Committee this morning let me say that the Panel is in close personal and continual touch with the men and women at the Kennedy Space Center, government and contractor alike, from the most senior to the most junior. It's uncanny how their situation fits with what Dr. Kay described this morning. He had it just about right.

That's not to say there is no cause for concern. A NASA reorganization, a NASA downsizing, and a privatization of the Shuttle launch process is a lot to happen all at one time. This prompts uncertainty on the part of individuals, both for their own futures and for the future of the human space program. The Panel realizes that budget pressures are the root cause of this course of action, but we feel that too much is going on at one time.

A better course would be say privatization with a more gradual reorganization followed by downsizing once there is some experience with the new doing business. As a matter of fact, we understand that some of the previously announced reductions in NASA personnel at KSC have been rescinded. We think that's good. But in order to keep down the uncertainty that pending reductions engender there will obviously have to be the requisite funding.

To this point the Panel is cautiously optimistic that safety at Kennedy has not been and will not be in jeopardy. This is in large measure the result of good and dedicated people with good and dedicated leadership. At some point though, when uncertainly becomes too great and when funding drops too low, even the best of dedication and leadership won't help. The Congress and the Executive are the ones who can ameliorate this aspect of the situation through funding.

In any case, the Panel is continuing to monitor the situation at Kennedy and we'll inform both the Administrator and this Committee as soon as we conclude that the situation is worsening.

As for the proposed management restructuring, the Panel noted with regret the resignation of Brian O'Connor from NASA. We understand his reservations about the changes and empathize with him. Nevertheless, we see no immediate safety implications in the move. That's not to say the Panel won't continue to monitor the safety implications of NASA management structure and the way things are being done. We will do so and in fact accelerate that monitoring, but our current position is that the management arrangements are the prerogative of management, and we will not comment until and unless we see signs of deteriorating safety.

Thanks very much. I'm ready for your questions.

Chairman SENSENBRENNER. Thank you very much.

Before getting to questions, Admiral, we have got Mr. Dan Tam who is the Space Station Business Manager of NASA in Houston.

[The prepared statement of Vice Admiral Robert Dunn follows:]

Statement of

ROBERT FRANCIS DUNN

Vice Admiral, United States Navy (Retired)

before the

Subcommittee on Space and Aeronautics

Committee on Science

United States House of Representatives

April 17, 1996

Statement of

ROBERT FRANCIS DUNN

Vice Admiral, United States Navy (Retired)

before the

Subcommittee on Space and Aeronautics

Committee on Science

United States House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

I am pleased to appear before you today to share with you the Aerospace Safety Advisory Panel's experiences while attempting to assess the impact of the recent and pending changes within NASA on safety.

In the current climate of reduced budgets and after almost a decade of safe operating experience under this new regimen, NASA must continue to streamline its operation without compromising safety. The Panel believes it is imperative that NASA maintain a high level of safety consciousness in all its activities. Safety functions cannot be allowed to become "routine." The safety organization must maintain its independence if it is to function effectively. It is vital that NASA management continues its dedication to risk reduction and risk management if NASA's research and exploration programs are to be successful.

In fact, that very commitment to safety might well be the root cause of recent concerns over safety voiced to our Panel, the media and the Committee. Employees of all involved organizations feel strongly the commitment to an American human space flight program. All know that a disaster or even a near-disaster would mean the end of that program...at least in our lifetimes. Therefore, when “an extra set of eyes” for inspection and supervision are taken away, when uncertainty about the future builds, personnel begin to worry that they may make that one critical mistake that leads to disaster. Those worries, then, get manifested as vocal and written concerns to supervisors, the media, the Congress and Aerospace Safety Advisory Panel..

While the panel has always taken seriously its mandate to monitor safety in all its manifestations, under the present NASA Administrator, Mr. Goldin, the Panel's access to project offices and personnel throughout NASA has been unprecedented. In addition, in personal meetings with the Administrator and other top management officials, the Panel has become convinced that NASA is committed to safety first, especially when it comes to human space flight activities. Moreover, virtually all NASA and NASA contractor employees, in particular those who deal directly with flight hardware/software, have a similar commitment to safety. At the Kennedy Space Center (KSC), from top management to the most junior, government civilian and contractor employee alike, the commitment to safety is as great or greater that I have found anyplace else.

Not to say there is no cause for concern. A NASA reorganization, a NASA downsizing and privatization of the Space Shuttle launch operations process is a lot to have happen all at once. This prompts uncertainty on the part of individuals both for their own futures and for the future of the Human Space Flight Program. The Panel realizes that budget pressures are the root causes of these courses of action, but we feel that too much is occurring at one time. A better course would be privatization with a more gradual reorganization followed by downsizing once there is some stability and experience with the new way of doing business. We understand that some of the previously announced reductions in NASA personnel at KSC have been rescinded. We think that is a good start. But in order to keep down the uncertainty that pending reductions engender, there will obviously have to be requisite funding.

To this point, the Panel is cautiously optimistic that safety at KSC has not and will not be put in jeopardy. This is large measure the result of good and dedicated leadership. At some point, though, when uncertainty becomes too great and when funding drops too low, even the best efforts of dedicated leadership won't help. The Congress and the Executive branch are the ones who can ameliorate that aspect of the situation. In any case, the Panel is continuing to monitor the situation at Kennedy and will inform both the NASA Administrator and this Committee as soon as we conclude that the situation is worsening.

As for the proposed management restructuring, the Panel noted with regret the resignation of Bryan O'Connor from NASA. We understand his reservations about the changes and empathize with him. Nevertheless, until the changes are fully implemented and assessed, the Panel is unable to see any immediate safety implications by the moves. This is not to say the Panel won't continue to monitor the safety implications of the NASA management structure and the way changes are being accomplished. We will do so and, in fact, will accelerate that monitoring. Our current position is that organizational management arrangements are the prerogatives of NASA management and the Panel will not comment until and unless there are signs of a deterioration in the commitment to safety.

This concludes my prepared statement. I would be pleased to answer any questions or discuss any matters that may be of interest to the members of the Subcommittee.

Chairman SENSENBRENNER. Mr. Tam.

STATEMENT OF DAN TAM, SPACE STATION BUSINESS MANAGER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. TAM. Thank you. Mr. Chairman and Members of the Subcommittee, good afternoon.

I appreciate the opportunity to testify before you regarding the business aspects of the International Space Station Program. As many of you know, this has not been an easy program with its cost and schedule constraints, technical and integration complexity and the sometimes surprising multinational interrelationship. It is through the dedication and diligence of thousands of people, not the least of which being your stable support. We appear before you today to say that our program is within budget and on schedule.

One of the more visible controls that we have on program is reserves management. Of the $17.4 billion that we committed to deliver a completed program we currently hold about $3 billion in reserves, and when we compare this amount to the costs before assembly completion it represents 32 percent. Being able to actually increase the program reserves after we have completed 40 percent of the work is something we can feel proud of, but by no means is it a reason to relax. In fact, the most difficult days are still ahead of us.

Some of you may have read or heard about cost and schedule overruns on the program. Let me go on record to say that the program is not nor is it expected to be in an overrun situation. The performance measurement system or PMS that we implemented across the program has indicated cost and schedule variances in the past few months. However, we must be careful how to interpret and apply the data.

The PMS variances from our baseline plan do not take into account contractor or program reserves. They also do not incorporate schedule margin or the work around flexibility that we have. The system does identify variances or problem areas so that we can apply proper management attention and resource allocations.

We have recovery plans in place and have started to see positive results. In short, because of the performance measurement system we were able to know the problems early. We tracked the problems early, and we worked the problems early, including escalating management attention to the many CEOs of the corporations. The system works and it is helping us manage this program.

But before too many people go around dropping their guard and say that life is good, I must point out that the next two and a half years are going to be the most challenging partly because of the flat $2.1 billion a year funding and the compressed schedule to expedite science utilization and save money. The money we have available through fiscal year 1998 is only a little bit more than the total requirement even with the healthy carryover that we have from the last two years.

We must keep our vigilance on cost and schedule control and keep working on changes so that the program continues to stabilize and work closely with our U.S. teams and international partners to do what is smart for the total program. Sub-optimization or local optimization is not a luxury that we can afford on this program.

As Mr. Trafton pointed out, we are well into the manufacturing and testing phases of the program. We have a good team in place, and we have proven that we can work well together. This is a program, in which we will find that the whole is indeed larger than the sum of its parts.

Again I thank you for the opportunity to appear before you today, and I thank you for your tremendous support to the program. I would be happy to address any questions you may have.

Chairman SENSENBRENNER. Thank you very much, Mr. Tam.

The gentleman from Florida, Dr. Weldon.

Mr. WELDON. I thank the gentleman.

I would like to congratulate Mr. Trafton on his promotion to Associate Administrator, and I would like to direct my first question to you.

The fiscal year '96 budget for the Space Shuttle Program as I understand it is $3.15 billion; is that correct?

Mr. TRAFTON. That's correct.

Mr. WELDON. How much of that is to be allocated to the United Space Alliance for their operations?

Mr. TRAFTON. Well, sir, I have to tell you we have put some numbers on the table. We're in the middle of negotiations with USA and I think it would be inappropriate in this forum to discuss this. I'll be happy to keep you informed as we proceed through the negotiations.

Let me just say that we all want the same thing here. We want to fly safely and we want to do what is smart with regard to going to a single prime in this program, and I think USA is on board with us on that.

Mr. WELDON. Well let me direct my next question to Mr. Black then. Given what you know about Congress' concern about a smooth and seamless transition from NASA to USA, during the transition how important would you say the level of funding is for maintaining that smooth and seamless transition.

Mr. BLACK. Well clearly, Mr. Weldon, it's very important that we enter into this change in a controlled way. We have implemented the early start, as I mentioned a few minutes ago, to start building our experience base. We'll start to take charge of Phase I of the program on 1 October, and obviously it would be desirable to move from the phase we're in to that phase with minimal disruption. As Mr. Trafton said, we're very, very early in the negotiations process, and I have no reason to believe, at this point, we won't be able to make that happen in that way.

Mr. WELDON. Would you consider receiving full funding or full transfer funding to be a very important first step being that this is going to be an on-going process?

Mr. BLACK. Having adequate funding is a very important first step, and what adequate is, is something we have to define over the next several months. We have had, as Mr. Trafton said, some very preliminary numbers laid on the table, and we have been assured that we are going to work through a process of very careful cooperative development of the changes in the management plan, work where we can find early savings, and we'll determine the adequacy of those numbers as we go through this process. I think we would be better able to answer your question at approximately the end of June of this year.

Mr. WELDON. Mr. Tam, you began your testimony talking about these huge reserves that the program has been able to accrue, but then you went on to say later in your testimony about the money situation becoming very tight. Could you explain that in a little bit more detail, because I'm a little bit confused about how that can happen so quickly, where you can set aside reserves, and then you have a very tight situation.

Mr. TAM. Yes, Mr. Congressman. The $3 billion reserve that I mentioned is the reserve between now and assembly completion, which is 2002. The way this program was structured back in '93 is that we would get a flat $2.1 billion a year for the next few years. Because it is a development program, it is very difficult to structure a program that you spend exactly the same amount of money every year. So what we have done is we tried to carry money from '93, '94 and '95 into '96, '97 and '98 because '96, '97 and '98 are the peak years for us. Once we can get over this hurdle, which is the next three years, our projection is that we actually will have money freed up to do other things.

So when I say we have $3 billion of reserve it's for the total program through runout. When I said we are tight for the next three years it's because we get $2.1 billion a year and we expect to spend almost all of that in the next three years.

Chairman SENSENBRENNER. The time of the gentleman has expired.

The gentleman from Texas, Mr. Hall.

Mr. HALL. Mr. Chairman, I thank you.

Mr. Black, I welcome you from downtown Pottsboro here. It's nice to see you again.

My question will go to Mr. Trafton. I have some concern about the Space Station, as well have, and the negotiations and the various changes in design. Up to today, I guess, I can acknowledge that participating with Russia maybe is the only way we could have saved the station and kept our station in the hoped for category. The Space Station Program has been shaken of course by problems relating to the Russian participation.

I just got back from Russia. I spent a week over there, but I spent it basically with candidates for President and I didn't get into the Space Station, but I gleaned from them that there was not money there then to pay the pensioners even, and that their state employees had not been paid in several months. That gives me concern about the projected delays in the delivery of the critical hardware, such as the service module that is critical to the cooperative agreement that we have. I understand Vice President Gore is reported to have received some assurances from Prime Minister Chernomyrdin that the problems are going to be resolved.

With that lack of money and that lack of support for the people that are the bedrock of that country, do you have a good feeling about whether or not they're going to be able to pay their contractors if they now owe the contractors, or what is the status of that?

Mr. TRAFTON. Well, sir, the first module to be launched, the FCB, the functional cargo block, is on schedule. In fact, it's ahead of schedule, and they will be launched in November of next year.

Mr. HALL. Yes, but we're paying for that. I'm talking about for what they pay for.

Mr. TRAFTON. The service module is behind schedule, and the Russians admit that very openly. The shell is manufactured, but they weren't outfitting it. We raised some questions at the very highest levels, as you are aware, and the Vice President has received a replay from Prime Minister Chernomyrdin in which he states that Russia will meet its commitments to the International Space Station, and he has given the necessary instructions to ensure timely financing of Russian participation in the program, and he agreed with the Vice President's recommendations that NASA and RSA should reconfirm critical milestones, and that they both would be provided periodic updates on these milestones.

In fact, at lower levels we have seen what is described as a trickle of funds to RSA and down to Energia who has the responsibility to build the service module.

We are assured at my level, that the Russians can make up any schedule loss, and that the service module will indeed be launched on time in April of 1998. We intend to monitor this very closely, as I described, through this process of exchanging milestones and keeping our senior leadership informed.

Mr. HALL. After the module, the other hardware like the science power platform and the research modules, what are the facts with their schedules?

Mr. TRAFTON. They're not behind. They should not have begun to manufacture them yet. Again, these will be part of the milestones that we will be tracking with our partners.

Mr. HALL. Does the Russian government furnish funds or funding for the contractors prior to the time of delivery, or do they pay it in conjunction with delivery, or do they pay it so much down and so much as the work progresses?

Mr. TRAFTON. Well, I'm not an expert on the Russian system, but it appears that they finance the Russian Space Agency incrementally through the year. One of the problems, as we understand it, is the Russian Space Agency has not received funding that had been promised by the government. Hopefully, the events of last week will see this problem go away.

Mr. HALL. I thank you, sir.

I yield back my time, Mr. Chairman.

Chairman SENSENBRENNER. Thank you.

The other gentleman from Texas, Mr. Stockman.

Mr. STOCKMAN. Thank you, Mr. Chairman.

I want to first thank Dan. Thank you for the briefing you gave us in Houston, and I appreciate you coming up today and all the work you have done.

Also, Kent, it's good seeing you again.

I have some concerns about some of the unresolved questions regarding the contract, and I understand that we can't really discuss that right now, but if you could articulate where we are currently in those negotiations it would be very helpful, sir.

Mr. TRAFTON. Mr. Stockman, we are in what we call the partnering stage. We're sitting down with USA and talking about work content and the management plan. USA owes us a written proposal at the end of May of this year, and then we'll sit down and go through that written proposal line by line with the objective of signing, as you've heard, signing a contract by October 1st of this year.

And as I stated earlier as well, we have put some numbers on the table. Unfortunately, they have gotten out, but it is inappropriate to discuss this. We are right in the middle of these negotiations. We are not going to do anything precipitous here.

Mr. STOCKMAN. Well let me ask you this. Are you at a disadvantage given that we kind of bought the product before we negotiated the product price?

Mr. TRAFTON. I don't believe so. Certainly Mr. Black probably has an opinion here, but we don't think so.

[Laughter.]

I mean look what we did with Boeing on Space Station. We picked Boeing as the prime, and then we sat down and negotiated a contract. That was more difficult. We have 15 years of experience with Shuttle, and we pretty much know what has to be done to fly the Shuttle safely. We've been looking at efficiencies and we've had functional workforce reviews and zero based reviews look at this, and we've been coming down a path in our budget and personnel slowly reducing. We know where we want to go, and we are going, I think, to be very fair in our negotiations with USA.

Mr. STOCKMAN. Kent, do you want to comment on that at all?

Mr. BLACK. Yes. I would describe where we are as the following. We decided back in January/February that it was pointless to go through a traditional process of reading an RFP, generating a huge voluminous cost package, having NASA evaluate that and going back and forth over the transom, if you will. We knew full well that what was likely to come out of that process was a number that NASA couldn't afford. The fact is that the run rates of the contracts to date are higher than we'll be able to afford in the future.

So we sat down and jointly said, look, let's take advantage of the knowledge that we have from 15 years of history, and let's clearly document what it has cost to do this job, the various pieces of the job, and then let's development decision packages that take us from where we are today to whatever we finally decide is the right level of cost for the contract.

After we do that, we'll summarize that, as Wil said, and then we'll go back to the arm's length process, and we'll say, okay, here is the cost, we have a well documented version of that coming from history and these are the changes we're going to make, and now we'll go off and negotiate a fee based on that cost.

Mr. STOCKMAN. Kent, let me ask a clarifying question. In order to negotiate a contract it seems like you would need, or you are articulating that you kind of know where you're going already in terms of the structure, correct?

Mr. BLACK. No, we really don't, and that's part of what we need to do over the next two months. We're going to be having teams work for each area. For example, there will be a team related to KSC, there will be another team on the Orbiter, there will be one for the Mission Ops in Houston and so forth, which will sit down and define where are we today in the way we manage it, and clearly today we have NASA basically in charge of all elements of these operations.

I like to view it as a pyramid where today NASA starts at the top and comes a good way down that pyramid and we have contractors at the bottom doing work. Somewhere out in time we want to arrive at a point where NASA is just at the peak of that pyramid and USA has taken on more of the job underneath. We need to define that end point and then come back and decide the timing as we go along the way.

Chairman SENSENBRENNER. The gentleman's time has expired.

The gentleman from Indiana, Mr. Roemer.

Mr. ROEMER. Thank you, Mr. Chairman.

Mr. Trafton, I would like to follow up on some questions that the gentleman from Texas was asking with respect to the Russian negotiations with the Space Station. He was asking about the service module, and let me just it in this context. Certainly I come at this, as you know, as the fly in the ointment here and the ogre at the birthday party and the skeptic at the Congressional hearing. I'm not a Space Station fan. But let's look at this thing.

The Russians right now have us with their finger in the grenade pin, and they're pulling it, and they're saying we want to renegotiate this, when they know it can have extremely detrimental impact on the budget, on the schedule, and on the continuation of this Space Station Program. At the same time I read on the front page of the New York Times that we're sending $400 million of taxpayers' money over there, and they're fighting a war against the Chetchins and killing people. They're also building something in the Ural mountains that they have come up with the money to spend on a weapons facility or a nuclear fallout facility or whatever it is. The New York Times just speculated. Yet, we're sending all this money over there, and they're renegotiating a contract with us at a very, very critical time that will cost us more money if this thing is delayed with the Space Station.

You have said "they are behind schedule." I want to know specifically what is the impact of this going to be, being behind schedule on the $2.1 billion that you've capped the Space Station cost at.

Mr. TRAFTON. Well, Mr. Roemer, let me start by saying that we're not renegotiating with the Russians. I mean the service module is their contribution to the station. So there is nothing to be renegotiated here by way of a contract.

Mr. ROEMER. But certainly, Mr. Trafton, if that and the science power platform and the research modules and a host of other things that they're providing, if those things are delayed and if they don't have the money to do those things and if they want to renegotiate some part of another aspect of this contract, we are in deep difficulty with integration, with scheduling and with the budget of the Shuttle.

Mr. TRAFTON. It is true that if the service module isn't launched on schedule in April of '98 it does impact the program. The FGB, as you know——

Mr. ROEMER. What I'm asking again, and I apologize for interrupting you, but I know Mr. Sensenbrenner will hit the gavel with my five minutes, is what is the impact on the budget?

Mr. TRAFTON. If we don't complete in 2002, in June of 2002, then we probably can't keep the program under $17.4 billion.

Mr. ROEMER. And what is the likelihood of that right now with the context of this negotiation?

Mr. TRAFTON. I think, sir, very small. They are behind schedule, but that can be made up. We know they can make it up.

Mr. ROEMER. I hear reports that there is an embargoed letter at the White House that may in fact have some kind of statement on the status of these negotiations from Chernomyrdin to Mr. Gore. Can you tell us more about this letter so that this Committee knows a little bit more from a taxpayer perspective what's going on.

Mr. TRAFTON. Well, sir, I did summarize it earlier, but I'll be happy to do it again. Prime Minister Chernomyrdin in his letter stated that there should be no doubt that Russia will meet its commitments to the International Space Station in full. He has given the necessary instructions to the Ministry of Finance to ensure timely financing of Russian participation in the program. He has agreed with the Vice President's recommendation that NASA and RSA should reconfirm critical International Space Station milestones and provide period reports on the status of the program activities to the Vice President and the Prime Minister.

Mr. ROEMER. Has that letter been released?

Mr. TRAFTON. No, sir, it has not.

Mr. ROEMER. Can it be released?

Mr. TRAFTON. That decision is being made at a very high level, sir, and I can't answer that.

Mr. ROEMER. I would hope that on something of such budgetary impact on this Committee that we would get access to an important letter like that, and maybe the Chairman could even help us get it.

Chairman SENSENBRENNER. He already has.

Mr. ROEMER. You already have a copy of the letter, Mr. Chairman?

Chairman SENSENBRENNER. I have not seen it.

Mr. ROEMER. I would hope that the Full Committee could see that when it is made available.

Chairman SENSENBRENNER. You have a better pipeline to the Vice President than I do on these issues.

[Laughter.]

Mr. ROEMER. I'm not so sure with my voting record some days if I do.

[Laughter.]

Chairman SENSENBRENNER. The gentleman's time has expired.

Now I want to follow up on what the gentleman from Indiana has said. Yesterday Administrator Goldin met with me in my office to discuss the problem with the Russians, and he said at that time that he had not seen the full text of the letter, but had the synopsis, which I believe he has given you a copy of, Mr. Trafton.

I share Mr. Roemer's concern, and I've told Mr. Goldin that I would like to see the text of the letter that Prime Minister

Chernomyrdin sent to the Vice President so I would be able to reach my own conclusions on it, and if the Vice President did not want that to be released I certainly would keep the confidence, but I did want to see the text.

And the reason, Mr. Trafton, why I wanted to see the text is, as you know, Congressman Lewis of California is, was the Chair of the Appropriations Subcommittee that has jurisdiction over NASA, and I spent 22 hours in Moscow on January 9th and 10th, and during that time we were promised by First Deputy Prime Minister Olik Soskevets that Russia would meet its commitments to the international community to construct what he had agreed to do in the Space Station on time and deliver them on time and that the Congress would get a letter so stating.

Well it took five weeks for the letter to arrive in the Speaker's office, and when it was translated the letter said nothing and it gave Russia an out that was wide enough to fly Space Station through.

Mr. Lewis and I responded to Mr. Soskevets asking for further clarification about the time the Vice President wrote Mr. Chernomyrdin. Mr. Chernomyrdin apparently responds more quickly than Mr. Soskevets does because Mr. Lewis and I have not received a response to our letter asking for clarification.

Now Soskevets did promise Mr. Lewis and me and Ambassador Pickering who was present at the meeting that the payments would be made by the Russian Space Agency to the Krunechev Engineering Works so that they could make up for the lost time as a result of payments not being made last year and thus forcing Krunechev to lay off the workers that its subcontractors hired.

There was one payment made the day after Mr. Lewis and I left of $10 million. Once that was spent apparently the work crews were pulled off the service module at Krunechev and it's sitting on the floor there. Now I don't think Mr. Lewis and I want to be put in the role of being Krunechev's bill collectors and having to go off to Moscow to send dunning letters to the Russian government in order to keep this on track.

My concern is that the very clear and straightforward representations that were made to me by Mr. Soskevets in Moscow were not followed up on. The letter that was supposed to be clear and unequivocal from Mr. Soskevets said nothing, and that's why I want to make sure that the letter from Prime Minister Chernomyrdin to the Vice President is not the same as the letter that Mr. Soskevets sent to Speaker Gingrich and Senator Dole.

Mr. Roemer and Mr. Stockman and Mr. Goldin are absolutely correct and so are you that if there is a delay in the Russians delivering the service module, which is one of the first elements to be launched, then that puts the whole launch sequence in a cocked hat and all these budget numbers that we've been working on, some of us to try to save the program by putting fiscal discipline in and others because they don't want to spend any money on this program at all, ends up being wasted effort on our part.

Now what I would like to know from Mr. Trafton and Mr. Tam is whether all this horsing around as a result of Russia not being able to pay its contractors to build what they're supposed to pay for with their own money has any budget impact on us by this time. Has it cost us more in terms of lost time, in terms of interminable meetings while the Russians come up with demands for redesign and asking for more money and all of the things that they've done, or we're just able to put this on the cuff, and it hasn't impacted financially on the program at all.

Mr. TRAFTON. Well, Mr. Chairman I understand your concerns about the letter, and I will forward your comments up the chain.

Chairman SENSENBRENNER. Mr. Goldin heard them yesterday.

Mr. TRAFTON. I would state to you that we have spent an inordinate number of hours in discussions with the Russians over some of their problems. From my point of view, it has not impacted our budget yet, and I'll let Dan Tam address that.

Mr. TAM. Mr. Chairman, you're absolutely correct. If the Russians do not fulfill their commitment to the International Space Station Program a lot of the hard work that we have done, including all of you, would have gone wasted, wasted in the sense that the expected savings that we have in terms of schedule and budget would go away.

To answer your question directly, so far to date, we have not had to take money from our 17.4 or the 2.1 because of what the Russians have or have not done, but that is not to say that we did not spend lots of time working on contingency plans and work around just in case they do not show up.

Chairman SENSENBRENNER. And that all comes free?

Mr. TAM. The time that we spend, not only doesn't come free, but we lose here and we get lots of bad things because of this. So, no, it is not absolutely free.

Chairman SENSENBRENNER. Thank you very much.

My time has expired, and I would like to thank all of you for presenting this very excellent testimony. I think that we may be inviting you back as more water goes over the Kubechef Dam in Russia.

Thank you very much.

The last and certainly not least panel is devoted to Outreach and Education.

We have two witnesses, Mr. Jim Pagliasotti of the Aerospace States Association, and Dr. Joel Snow, who is the Director of the Institute for Physical Research & Technology at Iowa State University, who informed me earlier today that he is married to a distant cousin of mine.

Excuse me, Dr. Snow, you are not, but Mr. Byrd, who is one of your colleagues who is here, is the one who is married to a distant cousin of mine. I misread the card. Sorry about that.

First up is Mr. Jim Pagliasotti of the Aerospace States Association.

Mr. Pagliasotti, you are recognized for five minutes and, without objection, yours and Dr. Snow's written testimony will be printed in the hearing record in full and you may proceed to summarize your testimony as you will.

STATEMENT OF JIM PAGLIASOTTI, EXECUTIVE DIRECTOR, AEROSPACE STATES ASSOCIATION

Mr. PAGLIASOTTI. Thank you, sir.

Mr. Chairman and Members of the Committee, I'm sure Joel and I feel like the caboose on a very long train, and we'll try to clear the tracks quickly here.

Chairman SENSENBRENNER. If I say, the control of the fright train is in the caboose and not in the engine.

Mr. PAGLIASOTTI. And the best ride I'm told, too, sir.

I'm very appreciative of this opportunity to talk to you about a subject that we consider to be vitally important. I am the Executive Director of the Aerospace States Association. ASA is comprised of delegates from 37 member States, including the home State of every Member of this Committee, except Minnesota, and we're working on that.

We represent the Governors of our States. We were appointed by the Governors of our States and as such ASA is the nation's only aerospace advocacy organization with direct ties to the Executive Branch of State government.

Because we represent our Governors, our primary interests are employment and education. How the civil space program impacts employment and educational opportunities in our member States are a vital concern of ours.

We've been asked to address the subject of outsourcing NASA's academic programs, or how to improve NASA's academic programs, and that's something we have given a lot of thought to.

We are firmly committed in ASA to space education. We are determined to see it become an integral part of the curriculum in our K-12 schools, and we really don't believe that the importance of space education can be overstated.

Math and science literacy is absolutely essential if our future workforce is to be competitive in the global market, and we've really seen that space education can be an integrator in approaching the study of math, the sciences and technology, and virtually any other subject as well.

Space education is the right thing to do for other reasons. We really believe that it's the quickest and most cost effective way to show the taxpayers of this country a return on their massive investment in space. Nothing really builds a constituent response more quickly than when parents see their children engaged in difficult subjects like math and the sciences, and when teachers see their students engaged actively and enthusiastically in those subjects.

Space education does work. We've had a lot of experience with it, and I know you all have looked at it carefully. Our opinion is that NASA has done a very good job over the last 5 or 10 years of making their materials much more relevant to the nation's teachers and the students, and it's a pleasure to compliment them on that.

The problem we see, and the real disconnect we see is in outreach. It's a massive job to do outreach to this nation's teachers and their students, and there is a disconnect that I think is always in place when you try to do top-down outreach.

We have believed for quite some time and have tried to demonstrate to NASA that it needs to partner creatively with the States and localities and with organizations like mine to expand the impact of its education programs.

We have listened all day long to these wonderful projects and programs that are being discussed, that you all fund, and have seen the problems that result from trying to fund all of these programs.

We really believe that these resources are important to our nation's economy, and we believe they're important to our students. In fact, I would suggest that there is no better use of the resources the Space Program produces than to stimulate the interest of students in the K-12 classrooms of our country.

We've heard today about things we would like to do with single-staged orbit vehicles and with programs like the NASP. There are a lot of things that the best minds in this country have been unable to provide us and there are a lot of problems that we've been unable to solve despite our best efforts.

We don't believe in ASA that those answers do not exist. We believe they exist in the minds of students in our nation's classrooms, and we think it's critically important that we continue to focus their attention on these problems, because those are where the answers are going to come. If we're really going to reap the harvest that space can provide for our country I think we have to focus our attention on education.

We have in Colorado created a program three years ago as an attempt to demonstrate to NASA what grassroots outreach can accomplish at the State and local level. We have in three years provided over 2,000 teachers with the education and the tools to do space education actively in the classroom. We have reached some 200,000 children at a cost of perhaps 10 cents apiece. We have gotten responses from those teachers saying that what we provided them was in 98.6 percent of their responses very useful to them in the classroom.

We have done this by bringing together the private sector, our State space-grant colleges, a number of interest groups together with our State Department of Education to really actively take space education to the teachers. We have provided ubiquitous access.

The problem I think with top-down outreach is that it becomes an insider's game. You know, if you're in Houston, Texas, or on the space coast of Florida, accessing a NASA space education program is not too difficult. If you're in rural parts of those States it's more difficult If you're from a rural State like mine in Colorado it's considerably more difficult. And I think with all the problems teachers have very few of them know how to access that educational opportunity. We have in Colorado demonstrated that it can be done. We know how to reach NASA's education programs, and we've been able to provide those.

Chairman SENSENBRENNER. The gentleman's time has expired.

Mr. PAGLIASOTTI. Well thank you very much.

[The prepared statement of Mr. Pagliasotti follows:]

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AEROSPACE STATES ASSOCIATION

April 17, 1996

U.S. House Committee on Science
Subcommittee on Space and Aeronautics

Testimony of the
Aerospace States Association
by
James Pagliasotti
Executive Director

Mr. Chairman and Members of the Committee

Thank you for this opportunity to speak to you about a subject of vital importance to my organization. My name is James Pagliasotti. I am the executive director of the Aerospace States Association (ASA). ASA is comprised of delegates from 37 member states who are appointed by the respective governors of those states. As such, ASA is the nation's only aerospace advocacy organization with direct ties to the executive branch of state government.

I am pleased to report that the home states of every member of this committee except one are members of ASA, and I want to assure Congressman Minge that we expect to have Minnesota on board very soon.

Because we represent our governors, our primary interests are employment and education. How our nation's civil space program impacts employment and educational opportunities at the state level is our concern.

We believe the historic changes that are taking place in the relationship between federal and state governments demand that the states have a voice in policy making at the federal level. Therefore, we are very appreciative of this opportunity to continue the dialogue with Congress that we began when ASA was formed in 1990.

The subject we have been asked to address is NASA's academic programs and the potential for outsourcing programmatic responsibilities to the states and localities. It is a subject of great interest to ASA and one we have given considerable thought.

ASA is firmly committed to space education We are determined to see it become an integral part of the curriculum in our K-12 schools. The importance of space education to our nation can't be overstated. Math and science literacy is absolutely essential if our future workforce is to be competitive in the global market. Space education has the potential to capture the imagination of our children and stimulate their natural curiosity. Moreover, it is uniquely able to serve as an integrator in the study of math, the sciences and virtually any other subject, as well

Just as aerospace is the integrator for our high tech industries, touching on telecommunications, supercomputing, environmental sciences, biomedical and biotech, and a host of others, so does space education provide an overarching subject for the study of math, physics, chemistry, biology, medicine, psychology, engineering, computing and a variety of other subjects.

And, space education is the right thing to do for other reasons. It is the fastest and most cost effective way to demonstrate to the American public a return on its massive investment in space. Nothing builds constituent support more quickly than when parents see their children excited about school work, when teachers find a subject that engages their students And it can be done for pennies per student.

Space education works, and in the past five to ten years, the Education Programs division at NASA has done a good job in making the materials they produce more relevant to the needs of teachers and students. For an agency that is so often criticized, it is a pleasure to compliment them in this matter.

However, there is in our opinion a very real and critically important opportunity to improve the impact of NASA's space education efforts at the local level, and that is by dramatically improving access. NASA makes a good faith effort to reach out to the nation's teachers and students, but there is a disconnect that never will be overcome through a top-down approach to outreach.

In my home state of Colorado, and I believe in your states as well, we have a constitutionally mandated obligation to provide a thorough and uniform education to every child through 12th grade. But Colorado is a rural state, and access to resources is problematic. Uniform education is an objective rather than a fact.

Accessing NASA's space education resources isn't difficult in Houston, Texas or Huntsville, Alabama, or along the space coast of Florida. But, for teachers in rural parts of those states, it is more difficult. And, for teachers in Michigan and Indiana, Kentucky and Montana, it is still more difficult.

What happens is that access becomes an insider's game. Those teachers, schools and organizations that know the ropes get the goods. The average teacher in Nappanee, Indiana or Bay City, Michigan, or even in San Luis Obispo, California probably hasn't a clue as to how to go about it, or the time to find out.

Providing access is a big job, one that is beyond NASA's ability to accomplish on its own. And, in this era of budget constraints, the difficulty will increase What NASA needs, we believe, is a creative partnership with an organization that operates within the states at the grassroots level. We believe ASA is that organization.

We have proposed a cooperative agreement with the NASA Office of Academic Programs to conduct Enhanced State-Based Teacher Outreach as a 3 year pilot project. The goals are 1) to determine the state of space education in a representative sample of schools in select districts throughout the nation; 2) provide a yearly update that measures progress in space education literacy as a direct result of this program; 3) conduct space education conferences and hands-on workshops for teachers, 4) provide follow-on training at the local level to sustain and further space education interest, and 5) provide a direct pipeline to the classroom for distribution of NASA educational resources

Education, after all, is the purview of the states. We believe that we at the state and local level can best determine how space education can meet the needs of our teachers and students. And we have demonstrated that we can reach large numbers of them in a very cost effective manner

State-Based Teacher Outreach is an extension of a model space education program developed in Colorado and exported through ASA to four of our member states. In Colorado, we have conducted the Space Education Initiative for the past three years We have trained more than two thousand teachers how to use space education to meet statewide standards in math, science and other subjects, and have reached several hundred thousands of our students at a cost of about ten cents apiece.

We have annually produced books of space education lesson plans and activities, conducted an annual competition for curriculum development with $1000 cash awards and scholarships to space camp for the winners, and, coordinated Space Day and Space Week activities throughout the state. Evaluations from teachers show that 98.6% of all respondents rated the program helpful to very helpful, with most rating it very helpful.

We exported the program to California, Delaware, Oklahoma, and Wisconsin. Each of them has a unique approach to implementing it, but each of them is seeing similar results. Additionally, we have worked with the Spaceport Florida Authority to conduct a series of suborbital rocket launches carrying educational payloads that we call "Rockets For Schools" The Chairman will be interested to know that the next launch will happen May 4 in Sheboygan under the sponsorship of the Wisconsin Space Business Roundtable and is expected to draw several thousand students from around the state

We have been successful because State-Based Teacher Outreach is a grassroots effort It is "bottom-up" rather than "top-down." Its key component is "teachers teaching teachers," a peer outreach process that provides a comfort zone for teachers who are unfamiliar with space education and its applications in the classroom And, our approach provides ubiquitous access.

But there is much more we can accomplish if NASA accepts our proposal. In addition to its academic goals, we will develop a metric for measuring not only the success of space education in the classroom, but for measuring the success of outsourcing academic and other programs from NASA.

Leveraging federal dollars at the state and local level will be an important measure of that success. The proposal we have submitted requests funding consideration in the $5 million range, or less than 4 percent of the current Academic Programs budget. Because of the leverage we can provide through our state departments of education, our space grant colleges, the private sector and other interest groups, we will increase the value of those monies by a factor of no less than three.

Our proposal is fully consistent with Education 2000 and NASA's own Zero Base Review. It meets the stated intent of Administrator Goldin, who has said he is going to outsource anything the agency currently does that can be better done elsewhere. And, it is clearly in line with the effort to move more responsibility and more control from the federal to the state and local level.

In its report to NASA Authorization last year, this committee and its counterpart in the Senate both recommended that the Agency engage in this program. Subsequently, Mr. Goldin met with us and pledged his support, which he reiterated to Senator Larry Pressler during hearings last month. Governor Tommy G. Thompson of Wisconsin, speaking as chairman of the National Governors Association and the Education Commission of the States, has written to Mr. Goldin thanking him for his full support of this program and expressing his interest in the outcome.

However, in our initial discussions with the director of the Education Programs office at NASA headquarters, we have been told that there simply isn't any money for such a program, that it is "...a zero sum game. What programs should I cut to fund yours?" he asked. That isn't a question I can answer because it is his decision, not mine.

I can only suggest that a program that has a demonstrated success in broadening NASA's outreach, that has shown an ability to dramatically leverage dollars for greater service to the end-user, and that can provide for the first time a true measure of the value of space education efforts in the classroom, deserves a test run.

It is my opinion that it may well take a directive from this committee, or perhaps even direct appropriations, to move this program forward in a timely and judicious manner. So, I very much appreciate this opportunity to make you aware of ASA and its proposal to expand state-based teacher outreach. On behalf of our 37 member states, our teachers and students, I thank you for your consideration.

Chairman SENSENBRENNER. Dr. Snow.

STATEMENT OF JOEL SNOW, DIRECTOR, INSTITUTE FOR PHYSICAL RESEARCH & TECHNOLOGY, IOWA STATE UNIVERSITY

Mr. SNOW. Good afternoon, Mr. Chairman and Members of the Committee. I'm pleased to be with you today to discuss the scientific and management expertise that's available to universities to help accomplish NASA's mission.

Iowa State is a major land-grant and space-grant university dedicated to education, outreach and research. It's not the biggest and it's not the smallest. It has a sponsored research budget of about $120 million a year, less than 1.5 million of which happens to be from NASA.

ISU is the Department of Energy's management contractor for the Ames Laboratory, and we also manage several sizeable research programs for the Federal Aviation Administration and for other agencies.

I want to focus on two particular strengths that we have that demonstrate how a university can help in the management of NASA programs.

First, we were asked to address technology transfer. Our Center for Advanced Technology Department is our technology transfer arm. It's an approved and internationally recognized organization for its approach seeking practical payoff from basic research.

The Center selects research discoveries from the ISU portfolio of current research activities on the basis of their practical potential. Then it invests in targeted, later-stage, value-added basic research and concurrently a marketing strategy is developed that is tailored to get each innovation rapidly into the private sector.

The bottom line about this is that it works, and it works extremely well. Since 1987 the Center has supported 107 innovations in this process resulting in 59 agreements with industry. This is a success rate that is far higher than is found at most other research institutions, and these opportunities came both from university faculty members and from the DOE Ames Laboratories. So we've done it from a university platform and from the federal laboratory platform.

We believe that suitably adapting our approach could significantly improve NASA's technology transfer effectiveness and, therefore, the practical payoff from the very impressive investments in basic research that is made through NASA.

For example, a cost effective State-based technology transfer consortium could be developed. This might combine the skills of other State universities with leadership from our Center for Advanced Technology Development and could quickly and efficiently bring a new focus to NASA's technology transfer function.

Land-grant institutions typically have strong links to industry. Most have access to assistance from world-class technology expertise in their engineering colleges, and many like ISU already have the capability to respond to NASA's needs.

Another ISU strength that could help NASA is through our internationally recognized Center for Nondestructive Evaluation. This Center conducts research and technology development on materials' reliability and on inspection techniques to detect flaws in safety critical equipment. It draws on the wide-ranging materials knowledge of the Ames Laboratory and other related ISU programs as well as its own special expertise in nondestructive evaluation.

The Center's pioneering computer-based inspection simulations developed in collaboration with NIST are already dramatically changing the way industry applies sophisticated inspection technology, and among its FAA programs the Center manages the Engine Titanium Consortium, which includes our subcontracting to the major jet engine manufacturers in a research collaboration to ensure the reliability of jet turbine components.

The FAA, the Air Force, NIST and 24 leading U.S. corporations help finance the Center's cooperative programs, and industry members such as Boeing, GE, Pratt & Whitney and Lockheed-Martin have been working with the Center since it first started, which indicates a high degree of consumer satisfaction. Based upon our industrial and federal laboratory collaborative experience we believe that ISU could help NASA in the management of its NDE research programs.

Finally to conclude, Iowa State knows how to conduct focused and innovative programs in research and technology transfers, and we can manage major federal research programs effectively in areas where we have special capabilities such as technology transfer and nondestructive evaluation. Corresponding capabilities exist in almost every State in the nation, and this skilled talent pool is readily available to NASA as it looks to improve its performance and reduce costs in the leaner budget years ahead. We hope that this possibility will be seriously explored.

[The prepared statement of Mr. Snow follows:]

House Space and Aeronautics Subcommittee Testimony
by
Dr. Joel A. Snow
Director

Institute for Physical Research and Technology
Iowa State University

April 17, 1996

Mr. Chairman, I'm pleased to be with you today to discuss scientific and management expertise that is available at universities today to help accomplish critical NASA missions in the future.

Let me start with my own institution. Iowa State is a major Land-Grant and Space-Grant University, dedicated to education, research and outreach. Our annual sponsored research budget is about $120 million; less than $1.5 million is from NASA. ISU is the Department of Energy's contractor for the Ames Laboratory and we also manage several sizable federal research programs for the FAA and other agencies. I will focus on two particular ISU strengths that relate to NASA's programmatic needs.

First, our Center for Advanced Technology Development or CATD. It is proven and nationally recognized for its technology transfer approach.

As a nation we invest billions each year in fundamental research. This investment continually expands the base of knowledge needed in the long term for future technologies, but it can pay off in the short term as well.

CATD selects research discoveries on the basis of their practical potential, then invests in targeted later stage basic research. Concurrently a marketing strategy tailored to get each innovation rapidly into the private sector is developed and implemented. It works. Since 1987, the Center has supported 107 innovations resulting in 59 agreements with industry, a success rate far higher than found at most institutions. Research opportunities come both from ISU and the DOE's Ames Lab. The technologies resulting almost surely would have stayed on the shelf without this incremental funding and aggressive commercialization strategy.

In a soon-to-be released Georgia Institute of Technology survey, nearly 70% of CATD's client companies responding stated that they had already introduced new products as a result of CATD. Only 13% would have pursued similar product development without CATD's value-added research.

We believe that suitably adapting our approach could significantly improve NASA's technology transfer effectiveness and thus the practical payoff from NASA's research.

It is quite conceivable that a cost-effective state-based technology transfer consortium could be developed. Joining the skills of other state universities with leadership from ISU's CATD could quickly and efficiently bring new focus to NASA's technology transfer function. Land-Grant institutions typically have strong links to industry and most have access to assistance from world-class technical expertise in their engineering colleges. Many, like ISU, already have the capability to respond to NASA's interests. We stand ready to contribute to further discussion of this approach.

Another ISU strength that can help NASA is our internationally recognized Center for Nondestructive Evaluation. This center conducts research and technology development on materials reliability and on inspection techniques to detect flaws in safety-critical equipment. It draws upon the wide ranging materials knowledge of the Ames Laboratory and other related ISU programs as well as its own unique NDE expertise. CNDE's pioneering computer-based inspection simulations, developed in collaboration with NIST, are already dramatically changing the way industry applies sophisticated inspection technology. Among its FAA programs, CNDE manages the Engine Titanium Consortium, which includes the major jet engine manufacturers in a research collaboration to ensure the reliability of jet turbine components. Other work of the Center has critical applications in areas such as aerospace, nuclear energy, materials, and transportation.

The FAA, Air Force, NIST, and 24 leading U.S. corporations support the Center's cooperative programs. Industry members, such as Boeing, GE, Pratt & Whitney, and Lockheed-Martin, have worked with the Center since it began, indicating a high degree of customer satisfaction.

Based on our industrial and federal laboratory collaborative experience ISU is prepared to help manage NDE research programs in support of NASA's needs.

To conclude, Iowa State knows how to conduct focused, innovative programs in research and technology transfer. We can manage major federal research programs effectively in areas where we have special capabilities such as technology transfer and nondestructive evaluation. Corresponding capabilities in other areas exist in almost every state in the nation. This skilled talent pool is readily available to NASA as it looks to improve its performance and reduce costs in the leaner budget years ahead. We hope that this possibility will be seriously explored.

I would be pleased to answer any questions you may have.

Supporting Material
for Testimony by

Dr. Joel A. Snow
Director
Institute for Physical Research and Technology
at
Iowa State University

17 April 1996

House Subcommittee on Space and Aeronautics

Biographical Sketch
for
Joel A. Snow

Joel Snow, Director of the Institute for Physical Research and Technology, came to Iowa State University in July of 1993. He administers and coordinates the programs of IPRT's 11 centers, with a broad mission of promoting interdisciplinary basic and applied research in the physical sciences and engineering; administers and oversees the management and operating contract for the Ames Laboratory, a government-owned U.S. Department of Energy basic and applied research facility; coordinates with programs administered elsewhere in the University to promote technology transfer in the physical sciences and engineering, and meets with federal, state, and private-sector representatives to establish and develop programs that meet the objectives of the Institute and that fulfill the University's commitment as a premier land-grant institution. Snow came to ISU following 5 years with the University of Chicago as Associate Vice President for Research and for the Argonne National Laboratory. He spent 10 years with the U.S. Department of Energy; 1 year with the Executive Office of the President as a senior policy analyst for science and technology; and 11 years with the National Science Foundation. Snow received the B.S. degree in physics from the University of North Carolina, Chapel Hill; the M.A. and the Ph.D. degrees in physics from Washington University, St. Louis.

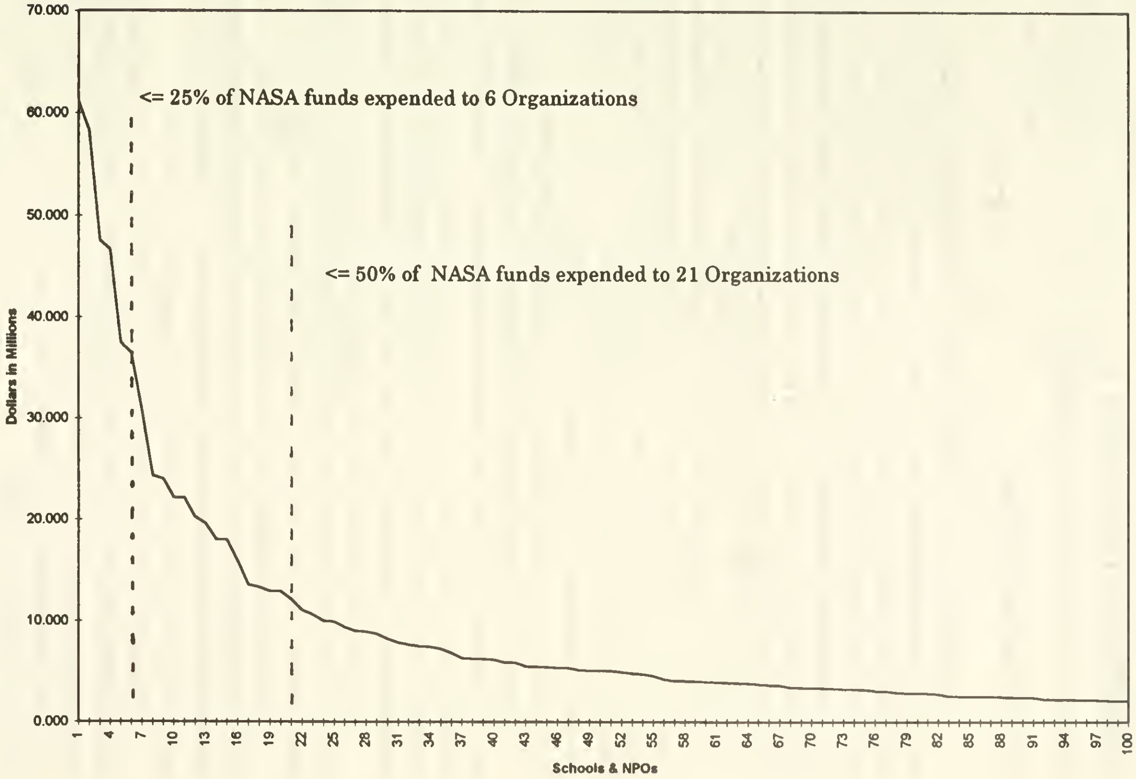
NASA-University Funding

NASA has involved universities in the work of the Agency since the earliest days of its existence. This is in recognition of the need for the technical graduates as potential employees for itself and its contractors. It also recognized the quality of research and capability in the academic world. The issue is not *IF* NASA is involving universities, but rather the extent and nature of the involvement. The enclosed chart is from the NASA Chief Scientist and shows how the NASA FY95 funding is distributed to the top 100 NASA schools and non-profit organizations.

With over 3,500 post secondary institutions in the nation and countless Non-Profit Organizations (NPOs), it is disturbing to see such a concentration of NASA funds in a few organizations. Even on a state basis, 50% of the FY95 NASA funds went to 17 states; primarily the states containing the NASA centers.

As explained in Dr. Snow's testimony, the nation has a great deal of untapped capability outside of the schools and states with which NASA traditionally associates.

NASA FY95 FUNDING TO UNIVERSITIES AND NON-PROFIT ORGANIZATIONS



IOWA STATE UNIVERSITY
Institute for Physical Research and Technology

Office of the Director
Office & Lab Building
Ames, Iowa 50011-3020
515 294-6551
FAX 515 294-2361

THE INSTITUTE AT A GLANCE

Iowa State University's Institute for Physical Research and Technology (IPRT), established in 1987, is a group of 11 research and technology-development centers with over a thousand employees. The Institute's principal mission is to focus its fundamental and applied research strengths on the development of new technologies by promoting interdisciplinary research in science and engineering. The Institute provides a diverse technological base for the development of new instruments, materials, and processes that will help foster economic development. Institute researchers include scientists and engineers from a wide variety of physical science and engineering disciplines; in addition, IPRT can easily call upon expertise from anywhere in the university. In 1995, IPRT's budget was approximately $60 million.

The Ames Laboratory, managed and operated by ISU under contract with the U.S. Department of Energy, is the oldest and largest of the IPRT centers. The Lab's origins lie in the World War II Manhattan Project, when ISU scientists developed an efficient process for purifying large quantities of uranium. Today, in addition to its traditional materials synthesis and processing expertise, the Lab has well-developed programs in environmental restoration, waste management, and high-performance computing. Several of IPRT's other centers grew out of Ames Lab programs and remain closely affiliated with the Lab.

To date, IPRT has assisted in the development of more than 10 new high-tech businesses and has entered into more than 50 license/option agreements with existing companies. These technologies include new magnetic materials and materials utilized in the electronics industry, computer animation software, analytical instruments used in chemical research and utility applications, and flexible film for alternative energy applications. Commercialization is also under way for a variety of other products and materials.

Over the last three years, more than 60 percent of the patents issued on ISU inventions have involved IPRT center activity. The excellence of IPRT research has been frequently recognized, and numerous IPRT scientists have received distinguished awards, including 11 R&D 100 Awards since 1987.

Through its outreach programs, IPRT sponsors technical services to business and industry. Private-sector clients can obtain such services as short-term no-cost technical coaching, materials analysis, nonroutine product testing and evaluation, microelectronics design and prototyping, and problem-solving technical research. Matching funds for research and development are available to eligible companies.

To complement its research functions, IPRT participates in the training of undergraduate and graduate students, supports yearly internships for women in science and engineering, and manages Science Bound. A team mentoring program involving ISU, the Des Moines Public Schools, and technology-based businesses in Des Moines, Science Bound seeks to encourage and prepare minority students in the secondary grades to pursue careers in science and engineering.

JOEL A. SNOW
Director

MEMBER CENTERS

•Ames Laboratory of the U.S. Department of Energy
(conducts fundamental research in energy and materials sciences)
Thomas J. Barton, Director (515–294–2770)
311 Technical & Administrative Services Facility (TASF)

•Center for Advanced Technology Development
(supports development of new technologies and assists in technology transfer)
Robert S. Harris, Associate Director (515–294–4055)
Lisa J. Kuuttila, Associate Director
151 Applied Sciences Complex II

•Center for Coal and the Environment
(develops technologies for energy & mineral production, preparation, and use)
William H. Buttermore, Director (515–294–3758)
288 Metals Development

•Center for Nondestructive Evaluation
(develops new noninvasive methods and instruments for flaw detection and materials characterization)
Donald O. Thompson, Director (515–294–8152)
115 Applied Sciences Complex II

•Center for Physical and Computational Mathematics
(conducts advanced research in computational dynamics and artificial intelligence)
James P. Corones, Director (515–294–4628)
329 Wilhelm

•Center for Rare Earths and Magnetics
(technical information center for scientific data related to rare earths)
R. William McCallum, Director (515–294–2272)
255 Spedding

•FAA Center for Aviation Systems Reliability
(develops instruments and devices for testing aircraft)
Donald O. Thompson, Acting Director (515–294–6770)
115 Applied Sciences Complex II

•Iowa Center for Emerging Manufacturing Technology
(develops computer visualization and concurrent engineering processes and technologies)
James E. Bernard, Director (515–294–3092)
2062 Black Engineering

•Materials Preparation Center
(prepares exotic and high purity metals)
Lawrence L. Jones, Director (515–294–5655)
121 Metals Development

•Microanalytical Instrumentation Center
(develops instruments to analyze alien and hostile environments)
Marc D. Porter, Director (515–294–5743)
45 Spedding

•Microelectronics Research Center
(develops advanced semiconductor technology)
David W. Lynch, Director (515–294–7732)
133 Applied Sciences Complex I

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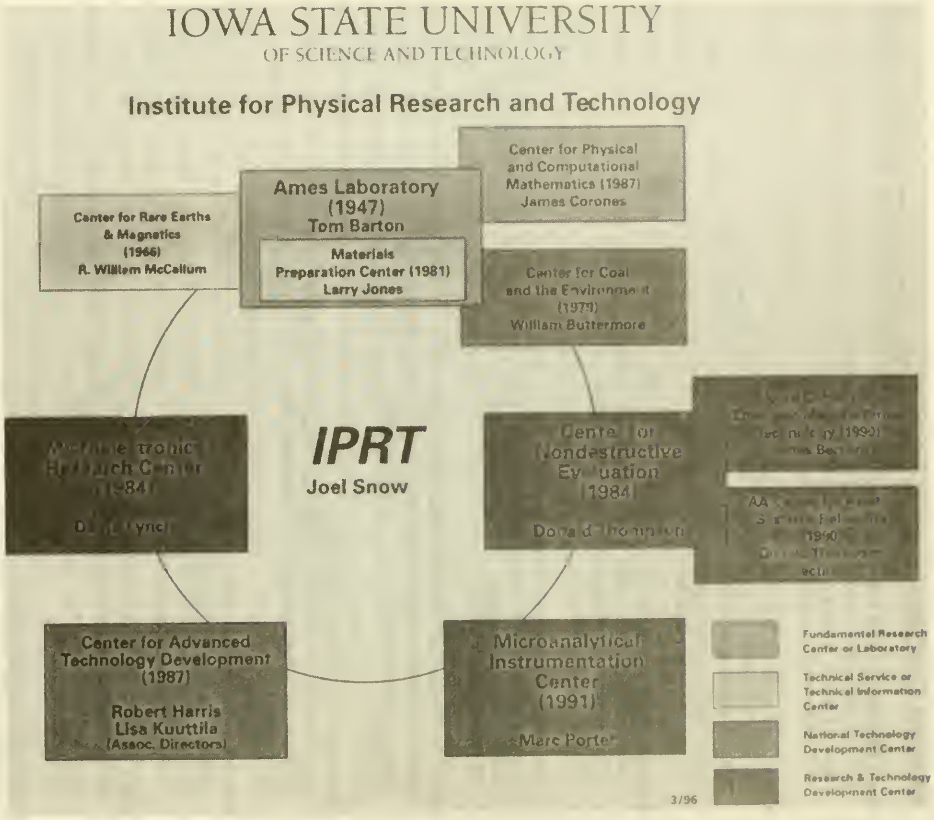


IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institute for Physical Research and Technology

IPRT
Joel Snow

Center for Rare Earths
& Magnetics
(1966)
R. William McCallum

Ames Laboratory
(1947)
Tom Barton

Materials
Preparation Center (1981)
Larry Jones

Center for Physical
and Computational
Mathematics (1987)
James Corones

Center for Coal
and the Environment
(1979)
William Buttermore

Center for
Nondestructive
Evaluation
(1984)
Donald Thompson

[illegible]
[illegible]
Technology (1990)
[illegible] Bernard

AA [illegible]
[illegible]
1990
Donald Thompson
[illegible]

Microelectronic
Research Center
(1984)
David Lynch

Center for Advanced
Technology Development
(1987)
Robert Harris
Lisa Kuuttila
(Assoc. Directors)

Microanalytical
Instrumentation
Center
(1991)
Marc Porter

▨ Fundamental Research Center or Laboratory
☐ Technical Service or Technical Information Center
▨ National Technology Development Center
■ Research & Technology Development Center

3/96

Ames Laboratory - Ames, Iowa

U.S. Department of Energy (DOE)

A National Treasure in America's Heartland

[illegible]

HELPING BUSINESS

[illegible]

ENVIRONMENTAL RESTORATION

[illegible]

NEW BUSINESS STARTUP

[illegible]

EDUCATION PROGRAMS

[illegible]

AMES LABORATORY AT A GLANCE

- ▲ Government-owned, contractor-operated research laboratory of the U.S. Department of Energy (DOE). Iowa State University operates Ames Laboratory for the DOE.
- ▲ Estimated annual budget of $35 [illegible]
- ▲ Approximately [illegible] employees, including [illegible] scientists and engineers.
- ▲ Annual payroll of $[illegible] million.
- ▲ Through Ames Laboratory, the U.S. Department of Energy provides approximately [illegible] research dollars coming into Iowa State University.
- ▲ Provides advanced materials [illegible] and government research [illegible] Industrial [illegible] Whirlpool and Pioneer Hi-Bred.
- ▲ Operates a Materials Referral System and Hotline which handles more than [illegible] inquiries annually from companies worldwide.
- ▲ Contributes technical expertise to Iowa companies such as Sauer-Sundstrand, Burlington Northern Railroad and Pioneer Hi-Bred International through the Iowa Companies Assistance Program.
- ▲ Since 1984, Ames Laboratory scientists have won [illegible] R&D 100 Awards.

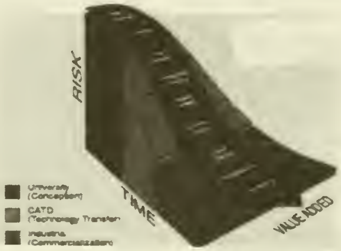
For more information contact
Steve Karsjen at (515) 294-1856
email: karsjen@ameslab.gov

CATD

The Center for Advanced Technology Development (CATD) is an organization within Iowa State University. CATD's mission is to provide Iowa and U.S. businesses access to university and government sponsored research and resources. The CATD is comprised of two offices that have separate functions.

OTC

CATD's Office of Technology Commercialization (OTC) is organized to reduce the risk for startups and mature businesses wanting to develop university research into commercially viable products and processes. The process starts when an idea is created as a result of research within the university. The researcher presents the idea to OTC. Based upon experience, market input, and potential, OTC decides whether or not to fund further research focused upon a market need. Funding can be from a combination of sources including federal, state, industrial and newly established Iowa Manufacturing Technology Center. Once the project is underway, OTC interacts with both potential users and producers of the technology to guide the research toward a market. The project turns the idea into a prototype that can be used for demonstrations. OTC also formulates an intellectual property strategy to ensure a market advantage can be obtained by a licensee. The process is completed when CATD negotiates a license that is beneficial for both the university and the licensee. The entire process is devoted to providing a use for the research and a market advantage for a company.



OCR

CATD's Office of Contract Research (OCR) offers help to companies to solve specific product or process problems. OCR markets Iowa State University's problem solving capabilities to companies across Iowa and the nation. Through the OCR companies can access expertise and sophisticated resources at the university. OCR contracts range from simple product testing to product or process design. Funding for a project is normally provided by the company although in some cases funding is available from the state of Iowa and the newly established Iowa Manufacturing Technology Center.

Call Lisa Kuuttila at OTC to inquire about:

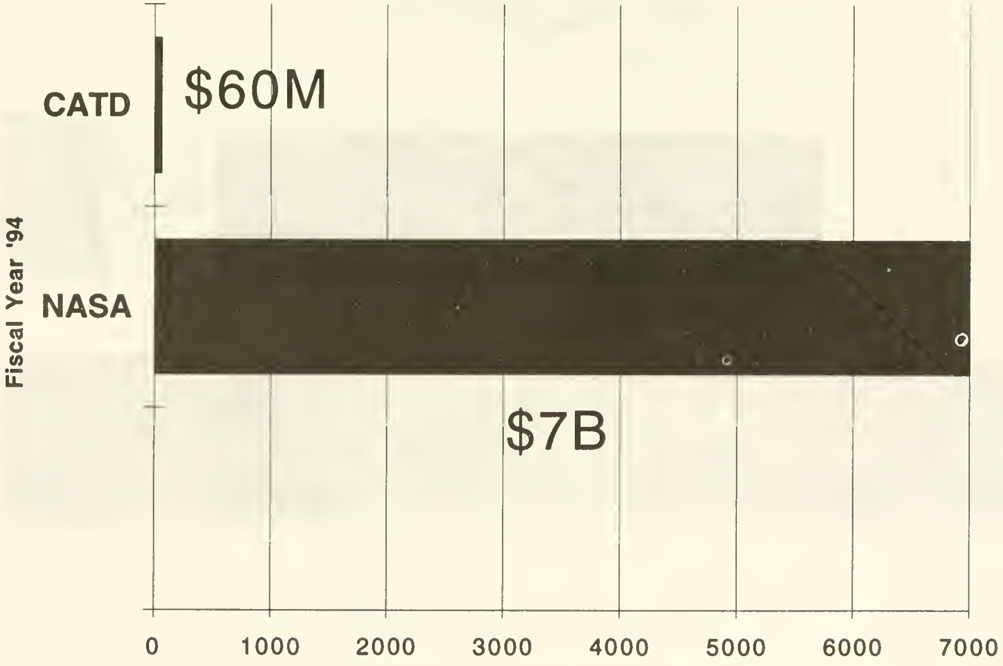
- New technologies available from Iowa State University
- Transferring your idea into a commercial product (if you are an ISU researcher)
- Ph. 515-294-2067 FAX 515-294-9519

Call Bob Harris at OCR to inquire about:

- How Iowa State University can solve your company's technical problem
- Developing new products or improved manufacturing processes based on your company's ideas
- Ph. 515-294-5808 FAX 515-294-9519

CATD Accomplishments: The Model Works

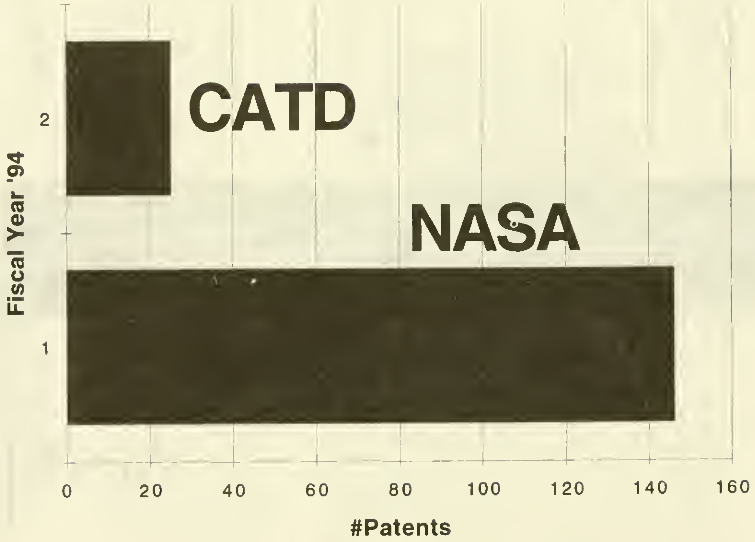
Research Budget Comparison



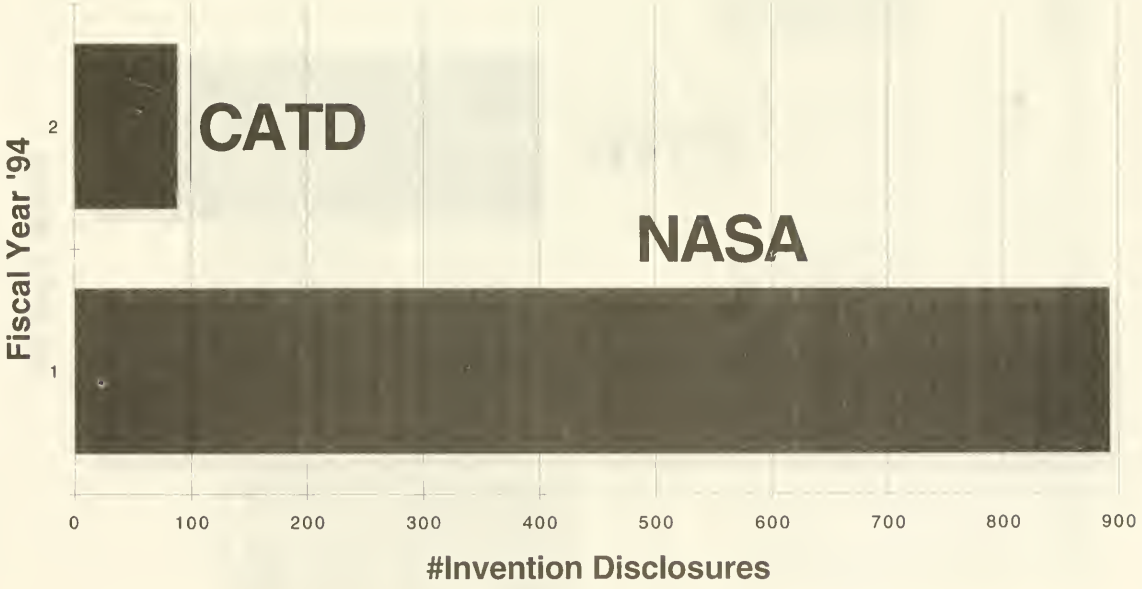
Iowa State University
Institute for Physical Research and Technology

Center for Advanced Technology Development

CATD Accomplishments:
The Model Works



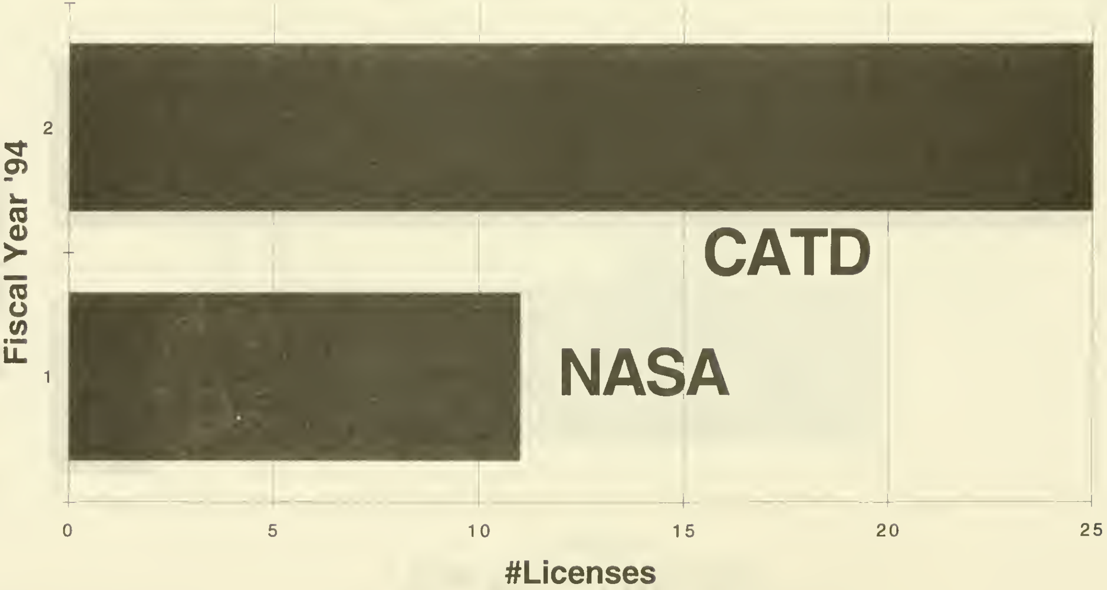
CATD Accomplishments: The Model Works



IOWA STATE UNIVERSITY
Institute for Physical Research and Technology

Center for Advanced Technology Development

CATD Accomplishments:
The Model Works



Center for Nondestructive Evaluation (CNDE)

Iowa State University

Advances in nondestructive evaluation can enhance the quality and reliability of manufactured products

A National Science Foundation Industry/University Cooperative Research Center since 1985

Center Mission Statement and Rationale
Nondestructive evaluation is the use of measurement techniques to noninvasively determine the integrity of a material component or structure. CNDE uses quantitative approaches to develop nondestructive evaluation as an engineering tool applicable throughout the life cycle of a component. The Center's emphasis is on the fields of aviation, transportation, energy, and manufacturing. Its mission is to conduct directed research that advances the science of nondestructive evaluation and ensures the integrity of structures and materials.

Research Program
CNDE conducts a full spectrum of research ranging from measurement models, which describe the fundamental interaction between probing methods and the flaws and properties of materials, to development of one-of-a-kind prototype instruments. Areas in which the Center is currently conducting research include—

- Ultrasonics
- Electromagnetic measurements
- Image enhancement techniques
- Microfocus radiography
- Magnetic techniques
- Microwave techniques
- Neural networks
- Nondestructive characterization of materials

Because the field of nondestructive evaluation requires a multidisciplinary approach, contributions from various engineering disciplines and physical sciences are essential. Faculty and scientific staff from three colleges and twelve departments contribute to the research efforts at Iowa State University (ISU). The Center's researchers currently include 27 faculty members, 16 professional and scientific staff, 2 IEEE Fellows, 1 ASM Fellow, and 1 member of the National Academy of Engineering.

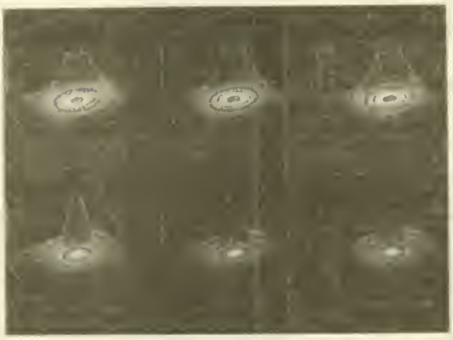
In addition to participating in the Industry/University Cooperative Research Centers Program, CNDE is active in two other major research programs—

- The Integration of Design, Nondestructive Evaluation, and Manufacturing Sciences Program, funded by the National Institute of Standards and Technology, incorporates product reliability and life-cycle costing into the designer's computer-aided-design station, which also ensures inspectability at the design stage.
- Problem-oriented nondestructive evaluation research, funded by the Materials Directorate of the U.S. Air Force Wright Laboratory, remains the keystone program of CNDE. This program is widely regarded as the founding program of modern concepts in quantitative nondestructive evaluation, and its research has led to numerous innovations.

Special Center Activities
Some of the Center's instrumentation and research accomplishments include—

- Development of various software packages for NDE signal interpretation and analyses in ultrasonics, radiography, and eddy currents. These new analysis packages have been used to solve critical problems by various organizations including Westinghouse, Association of American Railroads, Martin Marietta, and others.
- Design and construction of a new portable magnetic measuring system for hysteresis determination (magnescope).
- Design and construction of a new portable Barkhausen effect measurement system for evaluating surface conditions (magneprobe).
- Creation and development of an image processing package for x-ray image processing (image analyzer for enhancing x-ray radiographs of flaws in materials).
- Development of an ultrasonic instrument for the measurement of stress and texture.

A CNDE student adjusts an ultrasonic transducer for immersion inspection of composite materials.



Mathematical models allow simulation of nondestructive inspectability of structures. Here, comparisons are shown between model predictions of ultrasonic probe radiation patterns and experimental measurements.

A CNDE researcher (Dr. John Basart) performs computer enhancement on a digitized x-ray radiograph.

- Development of an online ultrasonic inspection system for bar stock and forging.
- Development of a unipolar ultrasonic pulse generator and receiver.
- Development of a self-calibrating eddy-current instrument for nondestructive testing.
- Creation of many morphological image processing routines including edge detection, background reduction, and particle separation techniques.
- Development and patenting of a procedure to nondestructively detect an undesirable phase (T_1 phase) in aluminum-lithium alloys.
- Development of neural network models for the sizing and classification of flaws using ultrasound.
- Invention of "Photoinductive Imaging," a new NDE technique that combines thermal-wave and eddy-current methods in a single inspection method. Three U.S. patents have been issued as a result of this invention.

Many companies including the Association of American Railroads, Amoco, ARCO, Boeing, Chrysler, EPRI, General Electric, Grumman, Hercules, Martin Marietta, McDonnell Douglas, Pratt & Whitney, Shell, Westinghouse, and others have used several of the advances developed by CNDE in their manufacturing and service businesses.

Most of CNDE's facilities are housed in ISU's Applied Sciences Complex. CNDE equipment and instrumentation at the Complex include a microfocus x-ray unit with digital camera, high- and low-frequency ultrasonic pulse instruments, eddy current and laser equipment for photoinductive scanning, very low-frequency magnetic scanning equipment, and a unique "test bed" for validation of models and work related to the role of NDE and materials in concurrent engineering and life cycle management.

Center Director: Donald O. Thompson
The Center for Nondestructive Evaluation
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(515) 294-7771 Fax

Center Evaluator: Dr. Anton J. Netusil
Professional Studies Department
N 247 C Lagomarcino Hall
Iowa State University
Ames, IA 50011
(515) 294-6216
(515) 294-4942 Fax

IOWA CENTER FOR EMERGING MANUFACTURING TECHNOLOGY

The **Iowa Center for Emerging Manufacturing Technology** (ICEMT) is a facility of the Institute of Physical Research and Technology at Iowa State University. Since its inception in 1990, the ICEMT has become highly regarded for its contributions to computer visualization both in manufacturing applications and in other fields. ICEMT provides a home for the integration of design and manufacturing at ISU. Support for ICEMT comes from the Roy J. Carver Charitable Trust of Muscatine, the State of Iowa, Iowa State University, the US Department of Commerce, NASA, NSF, ONR, and private industry. A particular emerging strength of ICEMT is in the area of applications of synthetic environments to engineering challenges. There are currently twelve faculty, two post-doctoral researchers, and over 60 graduate and undergraduate students working in association with ICEMT.

The Henry M. Black Engineering Building houses the Center, a 4,000 square foot facility which includes both the Computer Visualization Laboratory, a state-of-the-art computer graphics laboratory, and the Carver Laboratory, a small manufacturing laboratory with adjacent space for computing and offices. The strength of the Computer Visualization Laboratory is in research and development of graphics application software to meet special needs. The ICEMT Resources Table summarizes the laboratory's hardware and software.

ICEMT researchers take advantage of a very wide range of synthetic environments, from routine head mounted displays through the highly immersive FakeSpace BOOM3C. The most recent addition to the array of synthetic environments is CAVE++. **CAVE++ is a theater which surrounds the user with an interactive 3D environment. It is the largest and most capable CAVE in the world.** Research in CAVE++ will include a wide variety of human in the loop applications, including NASA-supported work in astronaut training.

Iowa Center for Emerging Manufacturing Technology

The Iowa Center for Emerging Manufacturing Technology is a premier applications facility for synthetic environments.

Areas of Assistance

ICEMT is a leader in the application of high-speed, high-quality computer graphics to meet a wide variety of technical challenges.

Extensions of our work in graphics applications now include the emerging technology of synthetic environments (SE). SE presents us with a new paradigm for interacting with computer images. This new technology replaces the monitor/mouse interface with head-mounted displays and instrumented gloves which allow users to interact with computer images using natural head and hand movements.

Faculty and researchers in the center are studying ways to use this new interface to help engineers design, evaluate, and manufacture products more efficiently.

The common thread which links the driving problems of interest to our research team is the consideration of very complex geometry. **We deal with a wide variety of applications, from physiology to design to manufacturing, where visualization of complex geometry is essential to problem understanding, solution, or communication.**

Current projects include the following research areas:

- collision detection
- design sensitivity
- distributed virtual environments
- dynamic surface modeling
- dynamic control
- force feedback
- kinematics
- optimization
- qualitative manufacturability assessment
- robotic kinematics and dynamics
- robotic controls
- SE/human interactions
- vehicle dynamics
- virtual manufacturing
- virtual design applications

The Iowa Center for Emerging Manufacturing Technology was established in 1990 with a grant from the Roy J. Carver Charitable Trust. The Center houses a manufacturing laboratory and the computer facilities and staff of the Visualization Laboratory, the Carver Laboratory, and the CAVE.

Twelve faculty and more than 60 students pursue research in the Visualization Laboratory, Carver Laboratory and the CAVE++. Researchers come from a variety of backgrounds including engineering, computer science, and mathematics.

The Center is a member of the Institute for Physical Research and Technology (IPRT) at Iowa State University.

Chairman SENSENBRENNER. Thank you, Dr. Snow.

The gentleman from Florida, Dr. Weldon.

Mr. WELDON. I thank the Chairman.

Dr. Snow, NASA has as part of the zero base review, which I think you alluded to in your testimony, set up these 11 science institutes with the first ones being at Johnson and Ames. Do you support this and, if so, why, and, if not, would you explain.

Mr. SNOW. Thank you, Mr. Weldon. The basic concept of moving research programs out of Headquarters and out of central laboratories is one that has proven itself in other agencies. In principle the institute concept is one that I'm sure can work.

Our concern is twofold. One is that if the institutes are in effect clones of the Centers and are not in effect fully independent, not-for-profit or otherwise separate institutions, then you'll have the same problem there that was addressed earlier this morning, that there always will be a built in situation of potential conflict of interest.

The other issue is that we believe that the size of the package is probably wrong, that 11 institutes will not lead to a very efficient set of research activities that can be usefully farmed out to existing institutions, and that's why you need to set up new institutions, if you go the route that has been discussed. My comments earlier were meant to show that at a certain level of aggregation a university can perfectly well manage that kind of a research program. Our DOE, Ames Laboratory, is about $35 million a year. We know how to do that.

Before I came to ISU I was at the University of Chicago, and there we managed the Argonne National Laboratory which has a scientific program that is about the same size as JPL, and, of course, Cal Tech manages JPL for NASA.

So it's clear that universities at several different scales can manage these kinds of programs, but in each case there is a fully arm's length relationship between the agency involved and the institution that is carrying out the work.

Mr. WELDON. Mr. Pagliasotti—did I pronounce that correctly?

Mr. PAGLIASOTTI. That's pretty close. I appreciate the effort, sir.

Mr. WELDON. ASA is requesting that NASA outsource programmatic responsibilities of its academic programs to the States, correct?

Mr. PAGLIASOTTI. Yes, sir, as a pilot project, correct.

Mr. WELDON. If ASA were to get an agreement with NASA ASA says that rural schools, and you define that as those that are far from a NASA center primarily, would get the same access to NASA in terms of space education as the schools close to, such as the schools in my district.

Mr. PAGLIASOTTI. Correct.

Mr. WELDON. Have any other agencies ever adopted a similar program to the one that you're suggesting?

Mr. PAGLIASOTTI. Well there are a number of grants obviously that are disseminated to the State Departments of Education and so forth. I don't know of any specific to this program that we are trying to implement.

We have long felt that NASA needs a partner at the State and local level to really be effective in getting space education into the classroom and have in fact demonstrated that again and again. Obviously, the Education Programs Office is facing the same kind of budget constraints that every other division within NASA is facing, and it's a lot to ask. But we look at the opportunities to leverage federal dollars at the state and local level as one that is critical at this time, and it's something that we can provide at a tune of, I would say, three or more dollars to one.

Mr. WELDON. Now just to educate me a little bit about ASA, the 37 States that are members, have the Governors and Legislators in each of those States placed a full-time person in charge of space education in those States, or are most of the people wearing two hats?

Mr. PAGLIASOTTI. Most of them are wearing several hats. It's a voluntary situation with the exception of me, and I receive a stipend. Everyone else is a volunteer. Primarily, it's Lt. Governors, Economic Development Directors and others with a special interest in the aerospace industry. We have, I think, a unique capability because of that to work as a bridge between the Federal and State Governments.

Mr. WELDON. Thank you. I see my time has expired.

Chairman SENSENBRENNER. The gentleman from Texas, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman.

Mr. Pagliasotti, I'll follow up on Dr. Weldon's questions. Now because your primary interests are employment and education and you're trying to determine how the nation's Civil Space Program impacts employment and educational opportunities at the State level you're asking that a $5 million fund, in that range somewhere, be the funding consideration, and how are you to leverage that? You're to leverage the $5 million you think three to one?

Mr. PAGLIASOTTI. Yes, sir.

Mr. HALL. How are you going to do that?

Mr. PAGLIASOTTI. Well I can use as an example the programs we've run in Colorado, Delaware, Oklahoma and Wisconsin. We are able to bring the private sector interest groups, other aerospace advocacy groups and the State Departments of Education into the mix. We have had in Colorado a very broad-based support for what we've been able to do.

Mr. HALL. From whom?

Mr. PAGLIASOTTI. From those groups we just mentioned. Lockheed-Martin provides us with funding, the State Department of Education provides us with funding and a number of groups along the lines of the American Astronomical Society and others have participated, and the Denver Museum of Natural History. We've had very strong support to leverage that seed money for greater impact.

Mr. HALL. Well I know that you've been in attendance here today, part of the time at least, and you know of the great constraints on the NASA budget.

Mr. PAGLIASOTTI. Yes, sir.

Mr. HALL. It seems to me, and I'm not sold either way, I'm willing to listen, that your organization would be kind of a middle man or middle woman or middle person in the conduct of NASA's educational programs.

Mr. PAGLIASOTTI. I think what we can provide, sir, is a real true read at the State and local level as to what best serves our teachers and our students. If you go with your hand out you get what you're given. If you go with cash you tend to get what you want, and we try to represent what our teachers and students want at the local level. Again I think it's a bottom-up rather than a top-down approach.

Mr. HALL. Then you don't think it's an item that the States themselves could fund without the $5 million from the Federal budget, from the NASA budget?

Mr. PAGLIASOTTI. Well, I think the States, obviously their purview is in education. I think the problem you have if you go to the Department of Education is space education is a small niche within the larger math, science and technology movement.

We in ASA are specifically committed to space education, because we see it as an integrator, a subject that can incorporate the study of all those subjects. That's a case we're working very hard to make to our State Departments of Education, and I would hope that over a period of time they would step forward with more and more of the funding for this program.

Mr. HALL. If they don't step forward with any funding, what are your intentions?

Mr. PAGLIASOTTI. Well, sir, to move on to the next State. We can only operate this in a select number of States, and through our ASA delegates we are identifying those States that are looking to participate.

Mr. HALL. Dr. Weldon was too nice to ask you where the pilot program is going to be. Where do you plan for it to be?

Mr. PAGLIASOTTI. We are proposing a cooperative agreement with NASA to identify those States and districts, but we would like to have a very representative sample, urban, rural inner-city and so forth, during which we would like to test the current state of space education and then the results of this program year by year, and I would hope after three years we could provide a matrix that would give this Committee and others who are interested a real true evaluation of what value can be gained from outsourcing, not just academic programs, but other programs from NASA Headquarters.

Mr. HALL. Well my time is about up, and I'll reread the rest of your presentation.

I thank you.

Chairman SENSENBRENNER. The other gentleman from Texas, Mr. Stockman.

Mr. STOCKMAN. Texas is like two bookends we've got on the Committee.

Chairman SENSENBRENNER. But the meat is in the middle.

[Laughter.]

Mr. STOCKMAN. Sir, I think you said it cost 10 cents per pupil and, if I remember correctly you, you said you had a 98 percent satisfaction rate.

Mr. PAGLIASOTTI. Correct.

Mr. STOCKMAN. I was wondering, and I'm not going to ask this question because my time is limited, but I wondered who the two percent were that would be unsatisfied.

I appreciate the fact that you're pushing down the authority. I mean quite frankly all of Congress is trying to do that. We're trying to take the welfare programs and other things and supply them back to the States.

My question which concerns me is what mechanism or guidelines have you set up to make sure that the money is going to be spent the way you guys allocate it?

Mr. PAGLIASOTTI. Well we obviously would define that in our agreement with NASA. As we have operated the programs in the past we have provided each State with general guidelines, and that is that this has to be direct outreach to teachers and students to provide them with space education capabilities, but each State does have a unique way of implementing this program.

In the pilot program we've operated to date there has been a different slant taken by each of these States who have operated this program. However, I think we've seen very similar results in every case, and it comes from going to the teachers and asking them what really works for them, and what we can do to provide them with more capability.

Mr. STOCKMAN. Will you be able to supply this Committee with written guidelines?

Mr. PAGLIASOTTI. Absolutely, sir. In fact, we've made a general proposal to NASA already, and we've been told by them, as you might expect, that there are no moneys, that this is a zero sum game, and they would have to cut other programs and so forth.

This Committee did recommend in its language to NASA authorization last year that NASA engage in Enhanced State-Based Teacher Outreach, which is the name of this program. The counterpart Committee in the Senate did as well, and Governor Tommy Thompson, who Chairs the National Governors Association recently wrote a letter to the Administrator urging him to pursue this. So I think we have strong support at the State level, but we do need to define the program in cooperation with NASA which, as you know, is the nature of a cooperative agreement.

Mr. STOCKMAN. That's a good point. They were talking about Space Week, and I know this, because in our district we celebrate it, and it would be a suggestion on my part that maybe you move it closer into the school year, as opposed to in the summer, so there is more awareness. In fact, I was on the campus near JSC, and the activities were less, because, quite frankly, there weren't as many students.

Mr. PAGLIASOTTI. School is out of session.

Mr. STOCKMAN. Yes. So if I can offer that suggestion.

Chairman SENSENBRENNER. Sir, in fact we work with Dennis Stone, who runs the Space Week Program, and we have discussed that very matter. We've tried to bring together all of the various programs and resources that exist out there and make them available to the teachers. That's a suggestion that comes from the teachers as well.

Mr. STOCKMAN. My last question is how will ASA do a better job of educating K through 12 than NASA in your opinion?

Mr. PAGLIASOTTI. Well, I don't think we can do a better job of educating them, sir, but we certainly can do a better job of hearing the teachers at the local level and hearing what best works for them and serving as a pipeline basically to make those resources available in the classroom.

Mr. STOCKMAN. I will also ask the Chairman if we can revise and extend our remarks at this time?

Chairman SENSENBRENNER. We have a Committee rule that prohibits that from being done. Request denied.

Thank you very much, gentlemen, for your very good testimony.

I would like to thank you and the other witnesses for your patience in sitting through this marathon hearing, and also give thanks to the Members, the staff, and, most of all, the court reporter, who has taken all of this wisdom down.

So, without any further ado, this hearing is adjourned.

[The Committee was adjourned at 3:10 p.m., subject to the call of the Chair.]

[The following material was received for the record:]

Responses to written questions to Mr. Trafton submitted by Chrm. Sensenbrenner resulting from April 17, 1996, hearing.

QUESTION 1:

As Associate Administrator for Human Space Flight, arguably you have the greatest challenge facing NASA today. Build the International Space Station on time and on budget, with a Space Shuttle system whose program management is in transition from the government to the private sector.

As NASA undertakes to transition Space Shuttle operations to the United Stares Alliance while simultaneously building the International Space Station, what steps does NASA plan to take in order to assure---

- USA's assumption of Shuttle operations will not adversely impact Space Station Assembly?
- That the Space Station assembly schedule can be met, with sufficient schedule and cost margins to assure mission safety?

ANSWER 1:

Sensitivity to the critical Space Station assembly was a high priority factor when NASA developed the non-competitive procurement approach for the transition to a single prime contractor. Additionally, the decision to transition to the prime contractor in a phased approach is also directly supportive of the commitment to the near year schedule criticality. Rockwell and Lockheed Martin are already performing almost 70 percent of the Shuttle program contractor effort, so the corporate familiarity and capability to perform as the prime has a proven historical base with regards to the operational requirements, the trained workforce to sustain the schedule and quality of the work. NASA has also decided to limit the Phase 1 activities of the consolidation effort to those operations contracts which were already directly performed by Rockwell and Lockheed Martin, leaving those contracts with significant development content or other corporate ownership aside for incorporation in Phase 2.

This approach will enable both NASA and the United Space Alliance to minimize the risk involved in the contractual and operational changes as transition to the single prime contractor occurs. Phase 1 is to include 12 of the 28 contracts targeted to eventually be consolidated into the single prime contract. These activities focus on the repetitive, manpower intensive contracts which perform the sustaining operations of the program--not major production or development work.

A phased approach which maintains the core corporate workforce should enable a safe and orderly transition to a new operational contractor while allowing for cost savings to be realized relative to today's operation. While the Space Station assembly schedule remains a significant challenge on its own merit, the transition to a prime operations contractor in this manner should only enhance the probability of success in meeting that challenge.

QUESTION 2:

If there are changes in the Space Station assembly sequence, how will these changes be accommodated contractually by the United Space Alliance?....

- For instance, if the U.S. lab launch is delayed for any reason, the schedule slip will impact Shuttle operations and USA's costs. Will changes to the Shuttle manifest be included within the USA prime contractor, or would such changes be paid for on top of the base contract?

ANSWER 2:

The Space Flight Operations Contract (SFOC) terms and conditions are still under negotiation with United Space Alliance. The basic conditions for contractual accommodation of manifest changes, however, are being defined within the same general bounds as would be experienced in today's contracts. The simple "first time" nature of the space business demands workforce, program and contract flexibility for manifest changes. The SFOC budget and contract planning will accommodate a range of manifest changes typically experienced over the first 15 years of the Shuttle program, but will allow for contractual relief (to NASA or United Space Alliance) for truly significant perturbations in program plans. The specific contract conditions for these cases will be definitively bounded prior to contract start in October of 1996.

QUESTION 3:

The amount of management change planned within the Shuttle program, combined with the cost cap on Space Station leave little margin for error.

- Has NASA established an "early warning system" to alert senior management if any combination of these many process changes conflict with flight safety and schedule goals?

- What mechanisms is NASA using to monitor mission quality during this phase of enormous change? Are these mechanisms adequate for senior management?

ANSWER 3:

While there is no specifically new "early warning system" being created for this purpose, there are well established venues for monitoring of the safety, quality, cost and schedule performance of every aspect of the program. The 15 year historical base of data provides an excellent platform for assessment purposes. Metrics have been developed over that period which are used at all levels of program execution, from individual work areas to monthly reports to NASA Headquarters. Specific contract functional metrics are being built into the SFOC Statement of Work to aid in the transitions process from "level of effort" management to "performance-based contracting." These metrics are targeted at assuring safety and quality are maintained in the proper priority while cost reduction measures are being pursued. Additionally, the contract terms and conditions will include a requirement that the performance evaluation of the safety and quality performance of the contractor must be sufficiently high in the NASA subjective assessment (exact level under negotiation) to qualify for any cost incentive sharing. The contract also includes a “look back” provision for longer term assessment of the quality of both the day to day operations and the maintenance of the quality of the systems and processes in a manner consistent with the Agency plans for continued operations. Senior management will have more than adequate visibility of the performance of both programs as provided by the normal contract reporting mechanisms, various budgetary and periodic program reviews. The Flight Readiness Review process is proven to provide management insight and visibility into technical, schedule, quality and safety issues involving the Shuttle program prior to committing to flight.

Responses to written questions submitted by Chrm. Sensenbrenner to Mr. Wisniewski resulting from the April 17, 1996, hearing.

The Committee requested, in pre-authorization questions, a runout of ZBR savings by fiscal year, similar to a development program runout. Instead, the Committee received a list (similar to that contained in Mr. Wisniewski's testimony) of ZBR strategies with some specific examples, but no timetable for achieving any specific strategy.

QUESTION 1:

When will NASA be able to forecast ZBR savings by fiscal year versus by conceptual approach or example?

ANSWER 1:

NASA has forecast ZBR savings by fiscal year by program area through FY 2000; this information on savings is the first attachment to Mr. Wisniewski's April 17, 1996 statement to the Subcommittee.

QUESTION 2:

Based on the FY 1996 runout, ZBR was charged with finding $439 million in savings for FY 1997. Was this cut achieved? If so, how?

ANSWER 2:

A plan exists to accomplish the savings for FY 1997 and we are confident that the planned reductions will be made. The plan is the first attachment to Mr. Wisniewski's April 17, 1996 statement to the Subcommittee.

QUESTION 3:

Between fiscal years 1997 and 1998, the ZBR is expected to produce $847 million in savings. How will these cuts be achieved?

ANSWER 3:

The plan by program area for FY 1998 is in the first attachment to Mr. Wisniewski's April 17, 1996 statement to the Subcommittee. We are confident that the planned reductions will be made.

QUESTION 4:

How does the ZBR work? Do you provide a dollar goal to the NASA field centers for cost reduction? Does Headquarters prescribe how the cuts are to be made?

ANSWER 4:

ZBR developed a plan to fundamentally change the way NASA does business. Implementation of these management changes resulted in a cumulative $4 billion in savings. New management concepts include Centers of Excellence and a clear definition of each Center's Mission; Lead Centers; full cost budgeting/accounting principles to better manage programs; and transferring program management responsibility to field centers from Headquarters. These management concepts have been built into the budget process which involves the Comptroller, Associate Administrators, and Center Directors. The outcome of budget deliberations determines the details and timing of realistic, updated annual plans to achieve the budget plan and management strategy.

QUESTION 5:

Last year, the Subcommittee proposed an "Asset Base" review to complement the ZBR effort. The purpose for reviewing all assets of NASA was to eliminate costs that are driven by the maintenance of facilities or equipment which may no longer deliver unique value to the space program, but which are nevertheless kept on the government's books.

Has NASA conducted an asset utilization study similar to that proposed by the Asset Base Review? If not, why not?

ANSWER 5:

Yes, NASA has conducted and participated in asset utilization studies; for example, the National Facility Study, the Zero Base Review, and the NASA-DOD Integrated Product Teams have all looked at asset based utilization. Each NASA Center has in place a plan to close, mothball, or demolish unneeded assets. The cost savings from these activities have already been included in the ZBR implementation plans.

QUESTION 6:

Please outline the steps that ZBR is taking to retire or consolidate capital assets which are no longer earning their keep at NASA. please be as specific as possible.

ANSWER 6:

Each NASA Center was given the target goal of 20-25% reduction in Current Replacement Value (CRV) of their facilities. These reductions have been incorporated into the ZBR implementation plans. Each individual Center has identified the individual facilities to be impacted and the year in which the action will occur.

QUESTION 7:

Will NASA be seeking to sell any of its facilities to private firms? How will NASA determine the most appropriate disposition of underutilized capital assets?

ANSWER 7:

No, we will not be seeking to sell facilities to private firms. Where there are unnecessary capital assets, we will excess the property through the General Services Administration (GSA) as required.

QUESTION 8:

According to your written testimony, NASA plans to achieve the bulk of its ZBR savings under the broad categories of "Restructuring" and "Privatization."

What are examples of restructuring versus privatization. Specifically, do you count the Shuttle single prime contract as a "restructure" or as a "privatization?"

ANSWER 8:

Restructuring is an immediate savings associated with reorganization, reengineering, streamlining and role changes. The elimination of program management at Headquarters is an example of restructuring.

Privatization is a savings associated with preparing, consolidating contracts to lay a foundation suitable for the eventual transfer of work and assets to the private sector - NASA only/dominant customer. The Shuttle single prime contract is an example of privatization.

No official definitions for restructuring or privatization have been provided to NASA.. The definitions employed in ZBR were based on senior management guidance.

Responses to written questions submitted by Chrm. Sensenbrenner to Mr. Tam resulting from the April 17, 1996, hearing.

QUESTION 1:

As the Space Station Program's business manager, you are intimately familiar with the performance of the program from a cost and schedule standpoint. While we await signature of the U.S.-Russian Memorandum of Understanding, it is important for Congress to know whether the U.S. Side of the house is in apple-pie order.

Is the U.S. portion of the International Space Station on time and within budget?

ANSWER 1:

Through the end of April, 1996, the program is approximately four weeks behind schedule and $60 million (1.5% of cost incurred) over budget. These variances are against the Performance Measurement System baseline, and do not take into account systems and flight margins which range from a few weeks to a few months, and $2.9 billion of program reserve which resides in the baseline budget. Workaround plans are currently in place to recover the schedule variance, which is within the margins available for assembly flights. Analysis is underway to determine the extent to which the cost variance is recoverable. Preliminary estimates indicate that some of the cost overrun will have to be covered by reserves.

QUESTION 2:

Are the U.S. contractors performing to cost and schedule?

ANSWER 2:

In general, the answer is yes. The prime contractor, including the product groups (McDonnell Douglas, Rocketdyne, and Boeing Huntsville) and their lower-tiered subcontractors, is the main contributor to the cost and schedule variances noted above. The other U.S. contractors are on schedule and within budget.

QUESTION 3:

Has NASA paid its bills to the U.S. contractors in a timely manner, so as to assure they will deliver their elements to KSC for launch on time and on budget?

ANSWER 3:

Yes, without exception, all U.S. contractors have been paid on time since program inception. While NASA had to struggle to assure adequate funding throughout continuing resolutions, all contractor payments were made without interruption to the program schedule.

QUESTION 4:

Does NASA have positive reserve levels, after all known threats are accounted for in FY 1997?

- Please identify the major cost threats being carried against program reserves for FY 1997.

ANSWER 4:

The program does have a positive reserve level in FY 1997 after taking into account all known threats: specifically, $193 million budgeted for reserves versus $164 million in identified threats. We also intend to carry over a portion of uncosted reserve from FY 1996 to supplement the FY 1997 budgeted reserve levels.

The major cost threats in FY 1997 are against the prime contract, including: the contractor's ability to reduce current spending levels as planned during the critical period of hardware deliveries; and, contingency pending resolution of the indirect rate issues with the Boeing company. In the non-prime areas, the major threat is the program's ability to fully achieve a 10% cost challenge put in place for both FY 1996 and FY 1997. Other significant threats include contingency for control module design effort and an alternative to the Canadian Special Purpose Dexterous Manipulator (SPDM) should our international partners fail to provide these critical systems.

QUESTION 4b:

How does the program decide it's time to pay a lien, that is, work its cost into the baseline program or use reserve funds for that purpose?

ANSWER 4b:

Reserves are reduced and a threat is incorporated into the program baseline (budgeted "above the line") when a firm decision has been made to include the item in the program, and no other source of funding or offset can be found.

QUESTION 5:

The General Accounting Office recently provided the Committee a copy of a study it performed for Congressman Dingell. The most disconcerting finding of the report, at least one which was all-too familiar to this Committee circa 1992, is an accumulation of uncosted changes—changes ordered by NASA, but not costed by agreement with the contractors.

Does the program have a problem with uncosted changes it ordered from the contractor and if so what is the nature of the problem?

ANSWER 5:

The program has authorized many changes to be added to the Boeing prime contract prior to actual negotiation. While the changes are not yet negotiated, they *are* budgeted within the $17.4 billion funding profile, either within the baseline budget, included as part of a formal contract change, or listed as a threat against budgeted reserves.

These undefinitized (authorized but not yet negotiated) changes were necessary either to maintain schedule or delete unnecessary work.. Problems have arisen not in maintaining program schedule, but in the amount of time needed to finalize the technical requirements, obtain formal proposals from Boeing and its subcontractors, and to complete negotiations. The time which elapsed between change authorization and negotiation in the past year was a direct result of the protracted time for Boeing and its Product Groups to complete negotiation of the baseline program as defined by NASA and Boeing in January, 1995, and the subsequent NASA consent to those agreements. This consent process was satisfactorily completed in April, 1996, and the parties have been actively engaged in completing negotiation on all changes.

QUESTION 5b:

How large is the accumulation of uncosted changes and how many changes are involved? How much money is involved?

ANSWER 5B:

Currently, the program has approximately 170 undefinitized changes at a contractor estimated value of $512 million. Proposals have been submitted for 74 of these changes at an estimated value of $235 million. We expect to negotiate these by the end of June. Proposals for an additional 75 changes will be submitted to NASA by June 30, and the contractor's estimate for these is about $200 million. We expect to complete these negotiations by the end of July. The remaining 20 changes are estimated by the contractor at $77 million and we expect these to be negotiated by late July or early August.

QUESTION 6:

According to the GAO, as much as $723 million has been identified as "Unpriced changes" that have not been made part of the baseline program. Does the program agree with this amount?

Please walk us down reality, then, from the $723 million. First, what is the program's estimate of total uncosted changes?

Second, what amount of these changes are already accounted for as current liens on program reserves?

How does the remaining amount compare to the un-liened reserves? Is there a shortfall? If so, how will the program accommodate this shortfall?

ANSWER 6:

The $723 million cited by GAO includes the contractor estimate for the purchase of the FGB from Khrunichev at approximately $200 million, the January 1996 contractor estimate of undefinitized changes discussed in the previous section, and overhead charges not included in the baseline contract. Negotiations on the FGB are now complete, and we are currently negotiating the cost of the authorized changes. The program is carrying adequate funding for the FGB and the authorized changes in the baseline budget. The extra overhead charges have been contested by NASA and are currently under review by the Defense Contract Management Command. Contingency for these charges is being carried as a threat against program reserves

Responses to written questions submitted to Col. Payton by Chrm. Sensenbrenner resulting from the April 17, 1996, hearing.

NASA's Reusable Launch Vehicle Program is at a critical milestone this year, as NASA has initiated the Phase 2 Cooperative Agreement Notice and industry proposals were due back on May 13.

QUESTION 1:

Explain the reasoning behind increasing funding for the X-33 flight test program in FY 1997.

ANSWER 1:

When developing technology that will be later demonstrated in a flight test, it is critical to have as complete an understanding of the technology at the component level as early as possible. Because this occurs earlier in the program, it allows flexibility to make technical choices without delaying flight tests scheduled later in the program. This approach reduces technical risk and thus increases the likelihood of successful flight of the test object. As industry has previously indicated to the Committee, the current X-33 program funding profile is not distributed appropriately to maximize the value of early investments. Moreover, the X-33 is scheduled for fly in March 1999, only about 33 months from the start of the program. The proposed funding allows critical long-lead items to be procured in a timely manner.

QUESTION 2:

If Congress approves the rephasing of X-33 funds, as requested, what impact will the rephasing have on industry's financial participation in X-33?

ANSWER 2:

Anything that reduces technical and programmatic risk is a plus and thus contributes to the likelihood that a decision to invest in the program will occur. In this case, however, the impact on industry financial participation if the funding profile is not changed is that they would likely be forced to reduce risk by increasing investment early in more expensive dollars while hoping to decrease investment later with less expensive dollars. This outcome increases the risk that total private sector participation in the program will be reduced.

QUESTION 3:

If Congress does not approve the rephasing of X-33 funds, as requested, will OMB be able to approve initiation of Phase 2, based on the OMB criteria.

ANSWER 3:

The rephasing of funds is not linked to the Phase 2 decision in any way.

QUESTION 4:

Without anticipating the Advisory Council's recommendation, do you believe the OMB criteria have been met?

- How does the NASA Advisory Council review relate to the planned "Non-Advocate Review" to be held in May?
- What potential "show stoppers" do you see in terms of meeting OMB's criteria to proceed with Phase 2?

ANSWER 4:

NASA believes that we have satisfied all of the technical and programmatic criteria necessary to make a positive decision to proceed. The findings briefed to the NASA Advisory Council (NAC) by subelements of the Council assert that all technical criteria have been met.

The review by the NAC is not related to the Non-Advocate Review (NAR) scheduled for May. The review by the NAC was a unique requirement resulting from the agreement between the Administrator and the White House that an external panel would review the criteria, and assess NASA's performance in meeting that criteria prior to a Presidential decision as to whether to proceed to Phase 2 of the program. The NAR is an internal NASA process which provides for objective assessment of programs by NASA managers.

The technical work accomplished, to date, suggests that pursuing single-stage-to-orbit technology development is a sound approach to reducing the cost of space launch. There are no show stoppers that are related to the OMB criteria.

QUESTION 5:

Should OMB decide its Phase 1 exit criteria have not been met (your testimony says "the Phase 2 decision is not a forgone conclusion") what would happen next?

- Would NASA continue Phase 1?
- Would NASA redefine Phase 2?
- Would NASA close down the X-33 program?

ANSWER 5:

The answer to that is dependent on the reason(s) for not proceeding to Phase 2. If there was a technical basis for deciding not to proceed then we have the option of mitigating the perceived risk by further technical research and development. If there are nontechnical reasons for not proceeding involving policy, we would require discussion as to what approaches for reducing the Nation's cost of space launch should then be pursued.

QUESTION 6:

The X-34 program hit a snag when its industry partners determined its design could not be closed and make a profit on the industry investment at the same time.

- Was the X-34 doomed to failure as a quasi-commercial effort?

ANSWER 6:

It is likely that the competing goals of technology development and profit motive clashed in this instance. Whether there were other partners who could have proceeded successfully is difficult to determine. NASA does not believe the X-34 was doomed to failure. There was a prudent decision not to proceed further by mutual agreement of the parties involved.

QUESTION 6a:

- What went wrong?

ANSWER 6a:

The X-34 projected return on investment was perceived to be too small to justify the investment required to build the specific vehicle being contemplated. This is the type of routine business decision made by industry managers faced with the responsibility of ensuring profitability.

QUESTION 6b:

- What does the X-34 experience say about the future use of cooperative agreements?

ANSWER 6b:

The X-34 experience demonstrates that Cooperative Agreements are an effective mechanism for encouraging accountability among the partners. Private sector organizations are incentivized by their investment to make hard decisions earlier, rather than later, as can occur when only Government funds are involved. Conversely, the Government is held to the terms of the initial agreement--no "change orders" are allowed without renegotiation of the agreement. The discipline imposed by the terms of Cooperative Agreements thus benefits both the partners of the agreement.

Questions submitted for the record by Mr. Sensenbrenner for Dr. Louis Friedman

Is there a level of funding necessary to sustain the "critical mass" of enabling Space Science activities, or conversely, is there a level below which the nation will lose a generation of astronomers?

In your testimony you state that the Pluto Express Mission should be started. How will NASA be able to start a large program with its current ideology focused on "smaller, faster, cheaper"? How should NASA prioritize its programs in order to see that Pluto Express gets started?

NASA has radically restructured the Space Science program to produce a higher mission flight rate, increase research results, and reduce per mission costs by factors of five to ten. Do you believe Mission to Planet Earth would benefit from this kind of restructuring or is it simply too late for Mission to Planet Earth to take that fork in the road that says, "Faster, Better, Cheaper"?

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Affiliations for identification only.

June 5, 1996

Rep. F. James Sensenbrenner, Jr., Chairman
Subcommittee on Space and Aeronautics
US House of Representatives
Washington, D.C. 20515-6301

Dear Rep. Sensenbrenner:

In response to your letter of May 21, 1996, I am pleased to answer your questions and review the transcript of the hearing of April 17, 1996. Enclosed, for reference, are the questions submitted for the record by you for me, to which I reply:

Level of Funding

Questions about this are very hard to answer. In general, The Planetary Society recommends a focus on programs and missions rather than on budgets and dollar amounts. We believe that the Congress also cares to decide on program content rather than arbitrary funding levels, which are usually generated by self-serving industries or agencies promoting budget rather than program.

We believe that the funding level approved in 1995 for NASA's space science program was consistent with a reformed and responsible program. It enabled a great deal (with missions like Hubble, Galileo, the new Mars Surveyor and Pathfinder, Discovery, and related research and data analysis). It also emphasized accomplishment rather than bureaucracy (and, in fact, led to severe cuts of NASA personnel and center and industry jobs). That level was $2 billion. If that level was held constant (adjusted upwards at the rate of inflation, perhaps two to three percent per year), we believe it would be a responsible program that would maintain the current momentum.

The projected decreases from that amount will not only cause us to lose at least some of a "generation of astronomers," but it could cause the United States to lose its painfully achieved role as a great and creative spacefaring nation -- pursuing knowledge and discovery throughout the solar system and the universe. The deleterious effect of this extends far beyond the astronomers who will be unable to work in the field. It extends to all of those who benefit from the new knowledge and discovery -- our youth and future generations, as well as our current generation.

Pluto Express Mission

The Pluto Express mission will be "smaller, faster, and cheaper" because it employs New Millennium technology that is being developed at the Jet Propulsion Laboratory specifically to this end. It should also be conducted as part of an international "Fire and Ice" program, which will utilize capabilities in Russia and Europe to enhance the results and reduce the cost.

Pluto is the last unvisited planet in our solar system. The public interest in this mission is significant and the exciting concept of the "Fire and Ice" program with the two former Cold War adversaries exploring the limits of the solar system together is an evocative and popular undertaking.

Five years ago a mission to Pluto was estimated to cost well over $1 billion. Currently, it is being developed to cost well under one-half billion dollars. It will be the pacesetter to a new generation of outer planet exploration (which may take us to the fascinating giant planet satellites, the Kuiper belt of comets, Neptune and Uranus, and perhaps even someday toward interstellar space). The Pluto Express is a high priority NASA new start. It is as important as the much more expensive initiatives in the other elements of the NASA program.

Mission to Planet Earth

The Planetary Society supports the currently well-balanced NASA program involving the five major enterprises: (1) Space Science and Planetary Exploration, (2) Human Flight, (3) Mission to Planet Earth, (4) Advanced Technology and (5) Aeronautics. The cuts that NASA has sustained over the past several years and the major reforms directed toward doing more for less have led us to conclude that the program is in balance. Thus, we support the funding request for Mission to Planet Earth.

Mission to Planet Earth is not a single mission or single spacecraft. It is really a program. Individual missions within that program probably can and should be restructured. Perhaps some of them can be made less costly. Indeed, some of that has already occurred and budget estimates today for Mission to Planet Earth are considerably less than they were several years ago.

We do not have the expertise to comment on individual elements of Mission to Planet Earth, but we do generally support restructuring and "faster, better, cheaper" approaches, while still supporting the overall program.

Enclosed with this letter are some changes to the transcript of my verbal testimony to the subcommittee. These correct minor errors in the transcription.

We very much appreciate the consideration of our views by the committee and the efforts being made to support NASA in a very difficult time for budget approvals. The enormous value of the Space Science and Planetary Exploration Program serves the country well. It is a value worth many times more than the cost. As we stated in our testimony, we are extremely concerned that space science is bearing the brunt of more special interest priorities in other areas at NASA, as witnessed by the recent amendment by Rep. Weldon which cut the space science budget.

Thank you for your interest and consideration. With every good wish,

Sincerely,

Louis Friedman

Questions submitted for the record by Mr. Sensenbrenner for Dr. W. D. Kay

What would you suggest for NASA to make the move from centralization to decentralization smoother? Also, can NASA leadership reduce the level of competition among NASA Centers since this creates further problems which could adversely impact mission outcomes?

see below

What are your recommendations to prevent the NASA Centers from placing their own specific interests ahead of NASA?

In my testimony, I noted that most studies of organizational behavior have found that decentralization is more consistent with research and development activities. Unfortunately, these findings do not take into account the unique internal structure of NASA. Competition among the various Centers has very deep historical roots. Indeed, given the fact that many of them were associated with the competing "space programs" of the Army, Air Force, and Navy throughout the 1950s, it can be said that the rivalries actually predate the formation of NASA itself. This strife was muted somewhat during the expansive Apollo years (a rising tide lifts all boats), only to come roaring back with the cutbacks that followed.

This suggests two things: infighting among the Centers—even when it comes at the expense of the agency as a whole—is so well-entrenched that it will be difficult to eliminate, and that the competition becomes even more intense during periods of retrenchment (such as is occurring at present). It is not clear what effect current NASA plans will have on this situation. In particular, it appears that the "Centers of Excellence" idea (whereby each Center is assigned a particular specialty) will discourage some types of competition, but encourage others. On the one hand, having a clearly defined responsibility reduces the uncertainty that can lead to conflict, and if that specialty is not duplicated elsewhere within the agency it minimizes the opportunity for Centers to "poach" upon each others' projects. On the other hand, increased specialization almost always leads to a *greater* sense of parochialism among an organization's subdivisions. Moreover, creating a unique role for each Center eliminates another possible remedy, namely the "military model" of regularly moving personnel (particularly in the leadership) throughout the organization. On balance, however, I feel that the advantages in terms of uncertainty reduction and the elimination of duplication outweigh the disadvantages, and that the current "Centers of Excellence" plan should be encouraged.

Finally, I would just note that *centralization*—a strict reliance upon hierarchical authority—is not necessarily the same as *formalization*—the presence of codified rules and regulations. If there is concern that NASA Centers will use their new-found discretion to pursue ends that are damaging to the agency as a whole, a possible response could be to establish *very specific* rules to address *the particular* behavior, while maintaining the increased autonomy of decentralization in all other respects. Of course, NASA Headquarters would need some mechanism to enforce such rules, but if this responsibility is clearly and precisely delineated, most of the advantages of decentralization can still be realized even as a specified problem is managed.

You mentioned in your testimony, both written and oral, your concern about turning the space shuttle over to a private contractor and whether it is such a good idea. The question was, with lower costs, will safety be an even bigger issue? Please expand upon your concerns.

I have three major concerns regarding this plan:

To begin with, I do not accept the premise of the question, i.e., I do not believe that contracting out shuttle operations will necessarily lead to lower costs. As I stated in my written testimony (and reiterated in response to a question from Congressman Tiahrt), contracting and other forms of privatization are supposed to lower an organization's operating costs by forcing it to deal with the influences and inducements of the market in a fashion similar to that of a private firm. In other words, contracting is not a "magic wand"—it is more like a surfboard that one uses to catch a wave of market forces. In the case of the space shuttle, I do not see—and no one has been able to show me—where the waves are to be found. There is only one contractor, and therefore no competition, as well as (for all intents and purposes) only one customer. Where, then, are the "market forces" that a contracting arrangement supposedly allows us to tap into? Of course, either NASA or United Space Alliance could, by fiat, cut back on the budgetary or personnel resources currently devoted to shuttle operations, but one would not need a contract do that.

Second, I briefly mentioned in my written statement my reservation over the use of the term "operational" in this context. I understand very well (and am even somewhat in sympathy with) NASA's desire to get out of day-to-day business of looking after the shuttle fleet. I believe, however, that we are setting up a false dichotomy here: to refer to something the scale, cost, and complexity of the shuttle as an "operational" system distinct from "R&D" technologies (which are held to be "more consistent" with NASA's mission) seems to me to involve considerable word play. Even acknowledging the massive efforts that have gone into improving the shuttle system, I do not see how it has even begun to approach the level of routine necessary to be called an "operational" technology.

Finally, I have avoided speaking directly about shuttle safety because I do not wish simply to repeat what others have said on the subject. Let me, however, suggest this: Congressman Weldon (Fla.) expressed his concerns during the hearing that STS operations were becoming too "budget-driven." I, of course, share his apprehension, at least up to a point. It is important to bear in mind that *all* technology development programs are governed to some extent by cost considerations. Engineers are trained from their earliest coursework to regard the cost of materials, components and so on as a major constraint. The result, in the words of engineer Henry Petroski (*To Engineer is Human: The Role of Failure in Successful Design*), is that every piece of engineering—every bridge, dam, automobile, or spacecraft—is to some extent a compromise. The question, then, is not whether STS is or is not budget-driven, but how much higher budgetary concerns have risen on the scale of priorities, and whether we are reaching the point where decisions on matters critical to shuttle safety are being governed by technical or by economic criteria. What all of this is leading up to is that it seems to me that the discussions of shuttle safety have so far been much too general. Those who are concerned with the issue need to focus more directly on the changes USA will make in specific systems, subsystems, and procedures. As was the case with the purported "cost reductions," how the shuttle performs will be based, not on the type of organization that is operating it, but rather the particular changes they make in the shuttle's operation.

Questions submitted for the record by Mr. Sensenbrenner for Dr. Anneila Sargent

In your capacity as Chair of the NASA Space Science Advisory Board, please answer the following questions for the hearing record. How will NASA be able to fund programs like Origins with the current decrease in the space science budget and the declining profile in the outyears? When do you expect that NASA will request funds for the Origins initiative?

Obviously the current decrease in the NASA's space science budget and the apparently declining profile in the outyears is disturbing for the space science community. For programs like *Origins* it is certainly a major concern since we are only at the beginning of this potentially very exciting program. This is a program that has caught the imagination of the public at large, not just scientists. Its success will undoubtedly motivate many young people to embark on the technological careers that are vital to the country's ongoing welfare.

As I pointed out in my original testimony, we believe that NASA Space Science can achieve most of its current goals as long as its budget declines no faster than that of the Agency as a whole. Elements of the *Origins* program are already encompassed in the Office of Space Science current plans. Thus since 1990 there has been a lively Research and Analysis program - of which I am a beneficiary - on *Origins of Solar Systems*; NASA has acquired a significant share in the Keck telescopes in Hawaii with the specific aim of enabling the community to develop technologies for detecting and understanding other solar systems and for searching for Jupiter-like planets; a testbed interferometer on Palomar Mountain in California has been funded by NASA as a precursor to the infrared interferometry that will be carried out with Keck I and Keck II. OSS has also encouraged large deployable mission technology studies that will be important for further *Origins* missions. And of course SIRTF and HST refurbishing missions are vital to the *Origins* program in terms of laying the scientific groundwork. If the OSS budget remains a stable fraction of the NASA budget, many of these elements of the *Origins* program can go ahead.

Major funding for dedicated *Origins* missions such as a space interferometer, an upgraded form of HST, and eventually a planet-finder, will require large sums and new initiatives. However, these are not anticipated before the first decade of the next century. In the meantime, the decreased budget could have an adverse effect in the sense that advanced technology mission studies may be difficult to fund.

NATIONAL RESEARCH COUNCIL
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June 7, 1996

The Honorable J. Sensenbrenner
Subcommittee on Space and Aeronautics
Attention: Rich Stombres
Committee on Science
2320 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Sensenbrenner:

In your letter of May 21, 1996, you asked me to elaborate on two issues from my testimony to the Subcommittee on April 17. I am happy to do so.

1. "Please discuss further your views on funding the NASA science institutes. What has NASA done to look into the concerns of the Space Studies Board?"

The proposed NASA science institute at the Ames Research Center has the potential for preserving the uniquely valuable elements of the science now resident at Ames. How well this will work will depend upon details of the arrangement between NASA and the new institute's host; upon the purpose, amount, and duration of transition funding to the new institute; upon the relevance of the institute's science in an era of decreased funding; and upon the objectivity of science management at Goddard and JPL (discussed under item 2).

The proposed NASA science institute at the Johnson Space Center is fundamentally different. Unlike the essentially independent relationship between Ames' Institute and the Ames Research Center, Johnson's institute will be funded by programs managed at Johnson, and the primary customer for the products of Johnson's institute will be the Johnson Space Center. If a few world-class scientists are attracted to the new institute, if the institute actively embraces quality science outside of NASA, if the institute's leadership is strong enough to be independent of Johnson's focus on operations, and if the conflict of interest issues discussed below are addressed, then science could be served well by the institute as it was served well by the lunar scientists who were resident at Johnson during Apollo. However, the life sciences at Johnson since Apollo have been perceived by the outside community as weak and isolated, and they have often acquiesced to apparently arbitrary operational constraints. The Board is concerned that funding incentives and organizational exigencies will encourage the new institute to assert its own interests and to filter outside scientists' access to Space Station. Science and the Nation are better served when scientists and science organizations openly compete with their best ideas and people.

NASA asked the Space Studies Board to comment upon the institute concept in the summer of 1995. We recognized the creation of institutes as a means of using competition within the space sciences communities to preserve good science while down-sizing. We also recognized that the quality of the outcome would depend upon details of the implementation. We advised NASA to move deliberately with the creation of its first institutes as a test of the concept. However, the issue came to us before we were fully aware of the migration of program management to the field centers, and before the decision was made to assign management of Space Station science to Johnson Space Center. I am aware that the Board's subsequent concern has been voiced to NASA through several channels. NASA has addressed some of these concerns by revisions to the original institutes planning, but implementation is not mature enough for comment on its outcome.

2. "In your testimony, you also state concern over the distribution of program management responsibilities from Headquarters to the field centers and a potential conflict of interest if an institute exercises program management responsibilities. Please explain this statement in more detail."

It is good practice to separate program management from responsibility for institutional health unless preserving the institution is the primary objective of the program. I believe that the success attributed to ARPA and to the NSF are largely due to their unwavering commitment to research quality, free of conflicts associated with building and maintaining institutional research capability. NASA science programs were managed from the agency's field centers during Apollo. Conflicts that arose between inside and outside science during the period of shrinking budgets after Apollo encouraged the migration of program control of science to Headquarters. It is ironic that today's shrinking budget is offered as the reason for moving program control back to the field centers.

Institutes that also exercise program management responsibilities are particularly susceptible to conflicts of interest. They will seldom have the relatively robust support enjoyed by field centers, which permits movement of resources among programs. An institute's survival will depend upon its sharing in each program that it manages. It is unrealistic to believe that an institute will be objective in "make or buy" decisions when its very survival depends upon some activities being kept in-house.

Much of the Board's thinking on the subjects of your inquiry is treated at length in a recent Board report, *Managing the Space Sciences*, and in a letter to NASA Chief Scientist France Cordova on August 11, 1995. A copy of each is enclosed.

Thank you for inviting my comments.

Sincerely,

Anthony W. England

A. W. (Tony) England
Member, NRC Space Studies Board
Professor and Associate Dean at the University of Michigan

UNITED SPACE ALLIANCE

June 14, 1996

Currently, two contracts held by Lockheed Martin and Rockwell the Shuttle Operations Contract (SOC) and the Shuttle Processing Contract (SPC) are in the process of being novated to the United Space Alliance under an initiative called "Early Start". The single prime contract (SFOC) is still under negotiation and will not be awarded until this coming October.

Question:
Can you please explain to the Subcommittee the purpose of the "Early Start?"

Answer:
On April 12, 1996, USA and NASA signed agreements for two major contracts designating USA as the prime contractor for Space Shuttle operations. With the novation of the Space Operations Contract, formerly held by Rockwell Space Operations Company, and the Shuttle Processing Contract, formerly held by Lockheed Martin Space Operations Company, USA assumed responsibility for all contract obligations on these two legal agreements.

The assumption of responsibility allowed USA to initiate an "Early Start" initiative, enabling USA to develop and implement compatible business systems (accounting, payroll, etc.) into our two sites in Texas and Florida and to transfer employees into USA. We were able to begin the process of putting business systems in Houston and Florida into place, a process that was completed as of June 1, 1996. As of that date all Rockwell Space Operations Contract employees in Houston and two-thirds of the Shuttle Processing Contract/Lockheed Martin workforce are now legal employees of USA.

The "Early Start" allows NASA and the corporations involved to move rapidly to a new way of doing business. It enables USA to participate in the partnering process and establish an organizational framework. Personnel supporting SOC and SPC will continue their standard procedures until modifications in workload are agreed to and effective transition plans are approved and in place. It has been important to quickly define roles and responsibilities in order to maintain personnel morale and efficiency and to ensure essential performance standards and the integrity of all programs.

As a result of the "Early Start", USA will be in a better position to ensure the safest possible transition of management roles while meeting the demanding requirements of the Space Station assembly manifest and simultaneously reducing operations costs. For example: USA and NASA will be better prepared to:

A) Implement civil service role shift from daily operational involvement and process oversight to insight and measurement through meaningful and objective performance parameters

B) Establish effective and meaningful measures of performance

C) Provide pre-contract time to solidify the NASA and USA team, and build the foundation for transition and concurrent operations of the Shuttle program. This will allow USA to complete phase I administrative transition of contracts and employees, and to validate effectiveness anc address most issues prior to contract start.

D) Allow effective transition of the control and configuration processes within the framework of the jointly developed (NASA and USA) management plan.

Question:
Will USA receive any fees from these contracts prior to the single prime contract award?

Answer:
No. By agreement between the parent corporations, the fees, as they had been negotiated for SPC and SOC, revert to the parent companies. The fees will be passed through from United Space Alliance to Rockwell for the NAS9-18000, SOC and the fees will be passed through from United Space Alliance to Lockheed/Martin for the NAS10-10900.

Question:
What happens to these novated contracts if the single prime contract negotiations fail?

Answer:
A novation reversal provision was included as part of each novation agreement signed between United Space Alliance, NASA and the parent corporations. This reversal clause states that the government has retained the right, at its sole discretion, to unilaterally reverse the novation agreement at any time for any reason. The agreement provides that the contractual relationship between the government and parent corporations will immediately revert back to what it was prior to the novation. Any contract change made during the period of the novation is also binding on the contract if there is a reversal to the original contract document.

Question:
What are the near-term effects this initiative will have on civil service or contractor FTEs?

Answer:
The intent of the Shuttle Flight Operations Contract is to consolidate the operations of the Shuttle program. United Space Alliance and NASA have been partnering to assume new relationships: the government in an insight role and the contractor in a performance/completion role. Clearly there will be reductions in FTEs required to complete the performance of the Shuttle program. We are currently working with NASA on defining reduced program requirements beginning in FY97. This activity is scheduled for completion this summer. To date it appears there will be no impacts in FY96. However, we do anticipate reductions in contractor FTEs after the end of calendar year 1996. We are not aware of NASA's near-term plans for civil service.

Recently NASA announced that the Office of Human Spaceflight (Code M) was to move to Johnson Space Center (JSC) as part of the "lead center "initiative.

Question:
How will this management change affect ongoing contract negotiations?

Answer:
This will have no impact on negotiations since the NASA authority resides with the Shuttle Program Manager and NASA's Space Flight Operations Contract (SFOC) Acquisition Team assigned to JSC. These personnel have been and are currently working daily with the USA to ensure that the work content, terms and conditions, and funding related to the SFOC are clear, understood and agreed to by the government and USA.

Question:
Will this restructuring require any fundamental changes to USA's operating plan?

Answer: No. Current NASA Shuttle program management and United Space Alliance interfaces are not affected.

A June 1995 GAO report recommended that the NASA should seek an independent organization to assess the safety implications of any future cost reductions.

Question:
Are there currently any unresolved cost reductions in the program?

Answer:
Yes, there are unresolved cost reductions, however United Space Alliance managers are continuing to work with their NASA counterparts to identify new ways of performing Shuttle processing and operations tasks. These teams are examining changes in methods that permit savings from current budget baselines. This shift of responsibilities facilitates streamlining of processes and a reduction in areas of government/contractor overlap. Significant progress has been made in reducing the amount of unresolved reduction toward achieving NASA's cost target. Resolution of final, agreed-to contract amounts for contract scope and responsibility boundaries should be formally documented this summer. At this time there appears to be no unresolved amount related to FY97.

Question:
Do you concur with the recommendation to seek an outside organization to assess future cost reduction implications for program safety?

Answer: Yes. USA welcomes the opportunity for any knowledgeable and technically competent outside organization to assess future potential risks to Space Shuttle safety. USA's number one priority in the Shuttle program is safety, not only of the astronaut crews during the Orbiter flights, but of every employee associated with the Space Shuttle program. USA has been very careful to review and evaluate every new innovative idea to improve and streamline the Space Shuttle Transportation System against the baseline safety, reliability and mission assurance history of the program.

Question:
What organization would you recommend for this critical role?

Answer:
NASA, in response to a request from the White House, has recently asked the Aerospace Safety Advisory Panel (ASAP) to undertake a focused review of the Space Shuttle program, concentrating on the safety of the Shuttle in light of internal NASA management changes, planned Shuttle hardware and software upgrades and Orbiter flight rate increases necessary to build and support the International Space Station. The ASAP is intimately familiar with Space Shuttle technical systems and operational procedures; and therefore well-suited to assume this critical responsibility.

Question:
Who will decide where to perform the Orbiter Maintenance Down Period (OMDP) for Atlantis (OV-104)?

Answer:
The OMDP for Atlantis is scheduled to start in the first quarter of FY98 and conclude in the fourth quarter of FY98. This effort is currently baselined to occur at KSC. NASA and USA will make the final decision to perform this task at KSC or Palmdale after a program review of all related activity, including potential impacts to Shuttle/Mir and International Space Station margin of safety and schedule.

Question:
What will be the factors in making this determination?

Answer:
Factors include: consideration of the potential impact to launch operations work flow at KSC, the degree of modifications required and the capability of KSC to perform this task. USA will provide the impact and risk assessment affiliated with this action and make a recommendation to NASA.

Question:
When will this decision be reached?

Answer:
In August 1996, the Space Shuttle program will conduct a review of this matter. Following completion of the review, the agency will announce plans for OV-104 Atlantis OMDP location.

As NASA downsizes, particularly with respect to the Shuttle workforce-

Question:
Are the efforts that the agency is making to encourage retirement-eligible personnel to exercise that option sufficient to retain the junior engineers which are so critical to the program's future?

Answer:
We recommend that this question be directed to the appropriate NASA spokesperson.

Safety of human and capital assets during all phases of the transition from current practice to single prime to privatization is the primary concern of Congress.

Question:
How will safety be assured as management structures are changed and authority is transferred from the government to private companies?

Answer:
USA's primary objective during the transition period is to ensure safety and minimize program disruption. To safely execute this transition, NASA and USA have developed a detailed Space Shuttle program management plan which addresses the orderly transfer of authority to USA only after verifying, through audit, surveillance and insight, that USA's execution of the Shuttle ground preparation processes and on-orbit flight support operations have been demonstrated to be adequately established. USA will initially perform the necessary processing and support operations in accordance with previously negotiated performance metrics until we have satisfactorily demonstrated mastery of each process.

NASA managers still consider portions of the program to be in the developmental stages, such as the solid rocket motors. As more experience is gained with this system, a decision will be made to fold it into the control of the prime contractor.

Question:
Who will make this decision and what will be the criteria for that decision?

Answer:
The NASA Program Office will make their decisions based upon the mutually determined readiness of USA to take on these additional responsibilities and the current level of R&D activity on these elements.

Question:
What incentives are necessary to maintain and improve the safety of operating the Space Shuttle?

Answer:
USA and NASA expect to negotiate a balanced set of incentives related to safety, schedule, and cost reductions that will clearly place safety above all else. An award-fee pool will be negotiated which will allow NASA to assess performance of USA against a predetermined set of metrics. Many of these metrics will be related to process quality and process discipline that are critical to mission reliability and safety. It is anticipated that the cost reduction incentive will include a minimum award fee grading threshold below which

the cost incentive is eliminated . USA is prepared to negotiate a major financial penalty to be imposed in the event of a catastrophic loss or accident due to negligence by USA. We believe these balanced incentives will ensure that the priorities are safety first, schedule achievement second and cost reduction third.

Question:
What additional safety concerns could arise from taking the next step, from single prime to an actual privatization?

Answer:
It is very difficult to speculate on additional safety concerns that would arise from actual privatization since this step is currently viewed to be beyond the initial six-year period of the SFOC contract. NASA and USA's goal is to arrive at a ready-to-privatize state by the end of the first contract in 2002. At this point it is difficult to assess what role USA will actually be performing at the end of this period and to what degree there will be a difference between full privatization and the single-prime contract role under NASA management. USA believes by the time this transition arrives, virtually all responsibility of assuring safety of flight will have transitioned to USA. The NASA interface will consist of a small program team. If this turns out to be the case, the risk involved in privatization would relate more to financial issues than to safety.

Estimates of cost savings to be achieved by consolidating contracts vary widely, as some include cost savings already achieved or being achieved under the present NASA system while others project savings that may not actually materialize.

Question:
Should NASA claim savings from the reduction in civil service personnel or the single prime contractor?

Answer:
This question seems to imply a competition between NASA and USA in achieving savings. In fact, all cost reductions whether from civil service reductions or other sources will benefit NASA. From a contract cost incentive perspective, savings from civil service reductions will normally not be included within the contract baseline if the changes result from the planned performance of the single prime contract. If, on the other hand, USA proposes innovative changes to that contract which could result in significant civil service reduction or other benefits, the anticipated savings sharing clause of the contract could in some cases result in inclusion of these savings under the cost incentive of the contract.

Question:
What incentives are appropriate for private firms to achieve cost reductions?

Answer:
As discussed above, it is important that a balanced set of incentives be provided. USA expects the negotiated contract to include three elements of fee for incentive:

- The award fee provision which will allow NASA to evaluate USA's overall performance and to award a portion of an available fee pool. NASA intends to heavily base this award fee on objective metrics that among other things will measure quality and adherence to process disciplines.
- The second pool will relate to schedule achievement and on-time manifest achievement without significant anomalies or problems.
- The third fee element of the incentive relates to cost reductions--wherein a portion of each dollar saved is retained by USA.

Overriding all the above, there will be a major penalty for a catastrophic loss or accident due to negligence on the part of USA. USA believes this group of incentives will ensure that safety comes first, achievement of the planned manifest second, followed by cost reductions.

For the cost reduction incentive to be effective, the contractor share must be sufficient to motivate the contractor to value current reductions over future business base. NASA and USA are both motivated to negotiate a set of incentives that will cause both parties to work toward these common objectives.

Question:
Is competition important in the selection of a single prime contractor or was the decision NASA made last November a wiser course of action?

Answer:
Competition is always important when a viable competitor base exists. In regard to the SFOC, we believe NASA's action was appropriate because it prevented a protracted and disruptive procurement from threatening the schedule and success of International Space Station assembly.

Lockheed Martin Corporation and Rockwell International Corporation together performed nearly 70 percent of the work intended for competition. With the joint venture of these two companies, the margin of safety for continued uninterrupted operations is enhanced to a level greater than either RIC or LMC could have provided as a single entity and we believe provides the safest transition option to a single prime.

Question:
What additional cost savings can be achieved by taking the next step, from single prime to an actual privatization?

Answer:
Without a clearer picture of the many issues surrounding privatization, this question is very difficult to answer now. We will have the experience and insight needed to answer this question in four or five years.

Question:
Do you feel confident that NASA's management restructuring will at least maintain the same level of safety that the Shuttle has experienced since return to flight?

Answer:
Yes. NASA's internal management restructuring as it relates to USA's single prime contractor status will be one of audit, surveillance and insight, which will maintain the same level of safety awareness that the Shuttle program has experienced since return to flight. USA as a single prime contractor, will produce processing efficiencies across the broad spectrum of Shuttle maintenance and support operations which should decrease the risk associated with the Space Shuttle program and continue the safety awareness established by NASA. This can be accomplished by focusing engineering and technical expertise and dollar assets on the areas which contribute the majority of risk to the Space Shuttle program, and reducing that risk through vehicle processing upgrades funding of hardware/software product improvements and continual independent assessments of the safety, reliability and quality assurance of the USA processes. Also, by combining several of the existing separate contracts (SPC, SOC, NSLD) into a single company, and having all other elements as subcontractors to this company (USA) communications of problems and anomalies within the team should be enhanced.

In its report, "Space Shuttle: Need to Sustain Launch Risk Assessment Process Improvements," GAO has made the recommendation that NASA ensures flight readiness review participants understand and agree on the minimum issues that should always be discussed at the review and the level of detail that should be provided.

Question:
Under the proposed restructuring, what role will United Space Alliance have in flight readiness reviews?

Answer:
As USA comes on-line as the single prime contractor for Space Shuttle operations, USA will assume a greater role in the Flight Readiness Review (FRR) process and in the presentation of the technical resolution data from the various in-flight anomalies and problem reports during the formal FRR. Currently USA is conducting internal FRR's and developing procedures in a timely manner prior to the SFOC contractual authority to proceed date. Each associate program manager presents a USA FRR briefing with all significant issues discussed to the extent that USA can make a flight readiness recommendation based on the status of work completed and the technical risk decisions that have been made. The USA chief engineer and the safety and mission assurance director are key players in this internal FRR process and have the authority and responsibility to independently assess the technical and safety risk of the completed work. The normal agenda includes subjects such as program integration, Orbiter vehicle status, ground operations summary, and flight operations forecast. Additionally, USA is developing an internal system of checks and balances to ensure the integrity of the Certification of Flight Readiness Process. The "Early Start" novation process has facilitated a gradual assumption of this vital accountability for USA and will allow 4-5 months of experience by contract award October 1.

The Aerospace Safety Advisory Panel's February 1996 Annual Report stated that "Obsolescence of Space Shuttle components is a serious operational problem with the potential to impact safety."

Question:
How do you propose to correct this problem?

Answer:
We agree with NASA on the need to upgrade the Shuttle because of concerns with obsolescence, both in terms of flight hardware and test equipment needed to validate flight hardware performance. NASA's FY97 budget submitted to Congress includes allocations for some Space Shuttle safety/performance upgrades including Orbiter improvements (such as installation of the Global Positioning System), main engine upgrades, SRB improvements, and super lightweight tank development. Allocations for launch site and facility improvements are also included.

We also need to take advantage of the many new technologies developed in recent years. One of the challenges is to find ways to apply X-33-developed technology to upgrade the Shuttle (e.g., new avionics, lightweight composite tanks, and new auxiliary power unit/hydraulic systems, etc.).

In addition USA is implementing a detailed process for identifying cost drivers from our current processing operations. We intend to prioritize these cost drivers to assist NASA in identifying the correct priority for enhancements and the ratio of development cost to payback for these improvements.

Question:
When do you expect to begin the layoff of shuttle work force contractors?

Answer:
It is our intent to use all possible avenues such as attrition and incentives to avoid massive layoffs. As an example, employees at KSC were offered voluntary layoff incentives this summer which resulted in a 150 headcount reduction. Should layoffs become necessary, we do not anticipate them until the second quarter of FY97.

Question:
Are you concerned about the high level of attrition which currently exists within the contractor work force?

Answer:
We are concerned about the attrition rates in selected high skilled areas and particularly those employees who work in mission critical areas. Overall some degree of attrition is desirable since it is clear that the workforce must be reduced over time. It is vital that USA be given enough time to thoroughly understand areas of overlap and inefficiency so we can focus reduction on these areas while protecting the most critical ones. USA will be requesting changes in the single prime contract to alleviate restrictive current contract provisions regarding employee wage rates for our employees. In many critical areas workers are currently paid below regional and national average pay scales, and often below equivalent civil servant pay scales. It is USA's intention to take some savings achieved through cost reductions and apply them to adjust pay scales where we are clearly not competitive and therefore losing workers.

Question:
What impact would the sale of Rockwell Corporation's space businesses have on the USA partnership?

Answer:
The Master Agreement (Joint Venture Partnership) between Rockwell International Corporation (RIC) and Lockheed Martin Corporation (LMC) contains clauses that specifically address changes to the "partnership" that established USA and its charter. This language provides for the legal guaranty of USA by the partners in the event of divestiture and other events that may alter the original agreement between LMC and RIC. Should a divestiture or other change take place, a change may occur to the affected partners members of the Advisory Board.

Question:
What effect, if any, would a divestiture in the near term have on contract negotiations?

Answer:
None. USA employees are responsible to and for contract negotiations with the government. And based on the guaranty specified in the Master Agreement, USA will continue as an alliance chartered as a legal entity to conduct specific business with and for the government.

Question:
Is USA in a position to compete for this business?

Answer: No. This type of action would be beyond the scope of the current partnership agreement.

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

Reply to Attn of. Q-1

May 29, 1996

The Honorable F. James Sensenbrenner, Jr.
Chairman
Subcommittee on Space and Aeronautics
Committee on Science
House of Representatives
Washington, DC 20515

Dear Mr. Chairman,

Thank you for permitting me to answer certain questions stemming from my testimony before your Space Subcommittee on April 17, 1996. These answers are included in the enclosure. As you are aware, in accordance with the NASA Aerospace Safety Advisory Panel (ASAP) charter from the Congress, the Panel's efforts are dedicated to safety while operating outside the NASA hierarchy. Since several of the questions you have posed for me are not within our charter, I have left them for response by NASA.

Sincerely,

Robert F. Dunn

Robert F. Dunn
Member
Aerospace Safety Advisory Panel

Enclosure

Questions Submitted by the
Honorable F. James Sensenbrenner, Jr.

Recently, NASA announced that the Office of Human Space Flight (Code M) was to move to Johnson Space Center (JSC) as part of the "lead center" initiative.

Question 1: Does this action place too much authority at one NASA Center, or for that matter, in the hands of one individual?

Question 2: Is this reorganization and return to the management structure in place at the time of the Challenger accident? The management organization was cited as a causal factor by the Rogers Commission (examined the causes of the accident).

Answers 1 and 2:

The ASAP's understanding is that Code M will not move to Houston but that authority and responsibility for Shuttle operations will reside there. The Panel's opinion is that this is a management action with distinct differences from the organizational relationships which pertained prior to Challenger. There are no immediate safety concerns but the Panel has the reorganization process on watch and will report immediately to all responsible authorities as soon as, and if, safety concerns develop.

A June 1995 GAO report recommended that the NASA Administrator identify any unresolved cost reductions within the shuttle program and further, to seek an independent organization to assess the safety implications of any future cost reductions.

Question 3:: Are there currently any unresolved cost reductions in the program?

Question 4: Do you concur with the recommendation to seek an outside organization to assess future cost reduction implications for program safety? What organization do you intend to task with this critical role.

Answers 3 and 4:

These questions deal with cost and are outside the purview of the ASAP.

There have been developmental problems with the alternate turbopump for the Space Shuttle Main Engine (SSME).

Question 5: How will this affect the date that upgraded main engines will become operational?

Question 6: Can you tell us what impact, if any, this will have on the schedule for space station assembly?

Question 7: When will NASA seek funding for Block III engine upgrades, and what is your estimate for the level of funding that is upgrade will require?

Answers 5, 6 and 7:

As long as NASA follows the rule, "Safety first, schedule second," the ASAP has no comment on either schedule or funding.

Question 8: Has the Aerospace Safety Advisory Panel (ASAP) seen any evidence during its review of contract consolidation that there is an unusually high rate of attrition of shuttle workforce contractors, many of whom have critical skills that are not easily replaced?

Answer 8: Yes. In our reviews at the Kennedy Space Center we have discovered that unusual numbers of people, particularly those with skills in demand elsewhere, are leaving. Thus far, the management at KSC, both contractor and government, have been able to cope, but the ASAP is monitoring closely the situation.

Safety of human and capital assets during all phases of the transition from current practice to single prime to privatization, is one of the primary concerns of Congress.

Question 9: How will safety be assured as management structures are changed and authority is transferred from the government to private companies?

Question 10: Do you feel confident that the restructuring will at the least maintain the same level of safety that the Shuttle has experienced since return to flight?

Answers 9 and 10:

Both NASA and the United Space Alliance have committed to maintain the high levels of safety demanded of the Shuttle program and, thus far, the ASAP has no cause for undue concern. But this is a major area of watch and investigation for us. We will continue to monitor and report incipient problems, when and if they appear.

In its report, "SPACE SHUTTLE: Need to Sustain Launch Risk Assessment Process Improvements," GAO has made the recommendation that NASA ensures flight readiness review participants understand and agree on the minimum issues that should always be discussed at the review and the level of detail that should be provided.

Question 11: Under the proposed restructuring, who will chair flight readiness reviews?

Question 12: Will a representative from NASA Headquarters be present at flight readiness reviews?

Answers 11 and 12:

These are better directed to NASA.

Thee Aerospace Safety Advisory Panel's (ASAP) February 1996 Annual Report stated that "Obsolescence of Space Shuttle components is a serious operational problem with the potential to impact safety."

Question 13: What was ASAP's recommendation to correct this problem?

Answer 13: Our recommendation and the backup thereto is appended to this enclosure, but, in summary, what is needed is better funding of spares and development of replacement subcontractors.

Question 14: Isn't there a need for the Associate Administrator for Human Space Flight to be seen as a neutral arbiter in disputes between the individual centers involved and therefore require that he remain at NASA Headquarters?

Answer 14: This is outside the purview of the ASAP and could better be answered by NASA.

The "Lead center" concept was determined by NASA to be a major contributor to the Challenger accident, in that it fostered poor communications between the project and program management. The Congressional investigation, as well as several NASA and external reviews have endorsed the concept of a headquarters managed program. As recently as November 30, 1995, in his testimony to this Committee, the NASA Administrator stated that NASA would "continue to use the management, communication, and independent reviews incorporated following the Challenger accident which have served the program so well in recent years."

Question 15: What made NASA decide to return to the pre-Challenger "lead center" management approach?

Answer 15: This question is outside the purview of the ASAP and could better be answered by NASA.

For years, the Shuttle Program Manager has been located in Houston, with responsibility to Washington for all but the highest level policy and funding decisions.

Question 16: What is the benefit of introducing another layer of NASA management (the JSC Center Director) between the Program Manager and Headquarters?

Answer 16: This question is outside the purview of the ASAP and could better be answered by NASA.

The underlaying reason for the post-Challenger change away from the lead center concept was to discourage any potential center-to-center communications failures among the constituent projects for the multi-center program. The historical tendency of centers to compete for work and/or resources was felt to be a natural environment for limited communications which could be alleviated by having all the projects report to a Headquarters level program manager. The GAO recently gave good marks to NASA's flight certification and safety communications systems.

Question 17: Why is NASA anxious to reintroduce an old risk factor into the already stressed Shuttle program by undoing an apparently successful management approach?

Answer 17: This question is similar to one raised by the ASAP and is under our investigation at this time. The ASAP will continue to review and monitor and will report as soon as and if a problem is manifested.

Since the post-Challenger restructure, the Johnson Space Center has played an important check and balance role for the Shuttle program.

Question 18: Now with the Center responsible for the program itself, who, if anyone, will provide that check and balance function?

Question 19: How does the independent safety and quality oversight function formerly provided by the JSC work now that the Center is responsible for program management?

Answers 18 and 19:

These questions are similar to ones raised by the ASAP and are under our investigation at this time. The ASAP will continue to review and monitor and will report as soon as and if a problem is manifested.

Question 20: Was this change done to reduce Washington workforce? If so, how many Shuttle program jobs will be deleted in Washington Headquarters?

Answer 20:: This question is outside the purview of the ASAP and should be referred to NASA for answer.

Given the exceptional external independent (including Congressional) oversight of the processes which NASA used to move away from the lead center system for both Shuttle and Station--

Question 21: What sort of process did NASA use to change back to it?

Question 22: Has there been any independent validation that it is a reasonable move?

Answers 21 and 22:

These questions are outside the purview of the ASAP and should be referred to NASA for answers.Answer 20

National Aeronautics and
Space Administration

AEROSPACE SAFETY ADVISORY PANEL

ANNUAL REPORT FEBRUARY 1996

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II. FINDINGS AND RECOMMENDATIONS

A. SPACE SHUTTLE PROGRAM

OPERATIONS

Finding #1

Cutbacks in government and contractor personnel and other resources at the Kennedy Space Center (KSC) and the planned transition of tasks from government to contractor workers will create a new mode of Space Shuttle operations. Those involved in day-to-day Shuttle operations and management are in the best position to determine how to maintain the stated program priorities—fly safely, meet the manifest and reduce costs, in that order.

Recommendation #1

Additional reductions in staff and operations functions should be accomplished cautiously and with appropriate inputs from the KSC NASA/contractor team itself.

Finding #2

Obsolescence of Space Shuttle components is a serious operational problem with the potential to impact safety. Many original equipment manufacturers are discontinuing support of their components. NASA is, therefore, faced with increasing logistics and supply problems.

Recommendation #2

NASA should support augmenting the current comprehensive logistics and supply system so that it is capable of meeting Space Shuttle Program needs in spite of increasing obsolescence.

Finding #3

The Return to Launch Site (RTLS) abort maneuver is one of the highest risk off-nominal Space Shuttle flight procedures. A Space Shuttle Main Engine (SSME) shutdown leading to an intact abort is more likely than a catastrophic engine failure. Exposure of an ascending Space Shuttle to the risk of performing the demanding RTLS maneuver might be significantly minimized by operating the Block II SSME at higher thrust levels at appropriate times. Certification of alternative Space Shuttle landing approaches for use during contingency aborts and installation of Global Positioning System (GPS) could also contribute to the minimization of RTLS risk (see Finding #5).

Recommendation #3

NASA should pursue with vigor efforts to minimize Space Shuttle exposure to the RTLS maneuver through all available means.

Finding #4

The Range Safety System (RSS) destruct charges have been removed from the liquid hydrogen tank of the External Tank (ET). The risk studies which supported this removal also suggested that the RSS charges had to be retained on the Liquid Oxygen (LOX) tank of the ET. It is preferable to omit as much ordnance as possible from flight vehicles to reduce the possibility of inadvertent activation.

Recommendation #4

Studies supporting the need for the RSS destruct system on the LOX tank should be updated in light of the current state of knowledge, operating experience and the introduction of the new Super Lightweight Tank (SLWT) to determine if it is now acceptable to remove the ordnance.

ORBITER

Finding #5

The Orbiter and its landing sites continue to be configured with obsolescent terminal navigation systems. The existing Tactical Air Control and Navigation (TACAN) and Microwave Scanning Beam Landing System (MSBLS) systems are increasingly difficult to maintain, vulnerable and expensive. Continued reliance upon them limits landing options in the event of a contingency

In short, the Space Shuttle Program appears to be properly managing risk. Hardware upgrades already in work, such as the Block II main engines, will provide even greater safety enhancements. The Program has successfully shed significant costs and can likely reduce expenditures even more without materially increasing risk as long as change is properly managed, given ample time and guided by those with first hand knowledge of Program operations.

Ref: Finding #2

The realities of supporting the Space Shuttle today are dominated by issues related to obsolescence. These issues can be divided into three broad categories:

- Obsolescence due to life limits or wear out of components and, in some cases, functional systems. This includes industry's abandonment of systems which were state-of-the-art in 1970 when they were adopted for the Space Shuttle.
- Obsolescence due to stringent new environmental requirements, especially with regard to repair and overhaul processes. The disposal and control of hazardous waste also impose a new dimension upon the support tasks.
- Obsolescence due to the inability to support component overhaul and repair because vendors have gone out of business or cannot support the Space Shuttle, for example, due to loss of skills and specific experience or unavailability of special parts.

Examples of current difficulties include a number of important avionics components (e.g., master event controller, signal processing assembly, several tape recorders) and airframe components, (e.g., CO_2 sensors, H_2/H_20 separators, water spray boilers, ammonia boilers). Major items such as the Auxiliary Power Units (APUs) are struggling from crisis to crisis in many cases due to subcomponent problems, and the Orbital Maneuvering System (OMS) pod problems are continuing.

Tracking and control systems for the multiplicity of logistics problems appear to be providing adequate information, but coping with the increasing obsolescence trends will inevitably lead to a higher rate of cannibalization or to "workarounds" which might impair safety. Better visibility into the entire subject of obsolescence should be developed if NASA is to avoid crises in the future.

Ref: Finding #3

Return to Launch Site (RTLS) requires an unusual and demanding flight profile fraught with the potential for error in a high stress abort situation. Should there be a shutdown of a main engine during the early part of the ascent, the RTLS procedure requires that the Space Shuttle continues powered flight after separation of the solid rocket boosters to expend propellants and then jettison the External Tank (ET). After solid rocket booster jettison, a powered pitch around must be performed so that the orbiter is literally flying backwards so that the thrust of the remaining Space Shuttle Main Engines (SSMEs) can supply a braking force. This is followed by a powered pitch down, a pullout and entry into the landing maneuver. All of this adds up to extremely complex flight dynamics including the need to fly through the SSME plume and its associated turbulence, heat and other off nominal flight dynamics. Remedies might include the following:

- Demonstration of operation of the SSME Block II at settings greater than 109% for use during an intact or contingency abort.
- Investigation of the thermal and structural loads to which the Space Shuttle would be subjected at higher power settings.
- Installation of a certified three string Global Positioning System (GPS) capability.

Questions submitted for the record by Mr. Sensenbrenner for Mr. Louis J. Lanzerotti

In your written testimony you state that, in the "context of the total civil space program, the impact of declining budgets on space science is influenced predominately by programs such as the space station and the space shuttle."

- Given that the station budget has been capped and NASA is in the process of reducing the shuttle program, how do you reconcile the increases in the Mission to Planet Earth (MTPE) budget requested for FY97 through FY00 with a declining space science budget during the same period? Even with the budget profile that decreases to $11.6 billion in FY00, MTPE is still expected to receive $1.55 billion.

- As a scientist, what do you see as the overall goals of the civil space program?

- What has your community done to provide recommendations for setting priorities within the context of a declining over-all NASA budget?

Responses for Questions Submitted for the Record from Dr. Louis J. Lanzerotti, Lucent Technologies

1. Studies of the Earth were long managed as a part of the NASA space and Earth sciences program. In this context, the balance within the civil space program is then one of balance between the human flight program and the principally robotic flight program. As I stated in my prepared Testimony, most space science, and Earth science for that matter, can be accomplished using robotic rather than piloted spacecraft. Thus, fixing the budgets for the piloted program in the out years and in a declining overall budget, means that the envelope for the space and Earth sciences will continue to shrink.

   There are great opportunities for significant discoveries waiting to be made in the space and Earth sciences. Hopefully the balance between piloted and robotic flight will be tended to so that these opportunities can be vigorously pursued.

2. I need to state very clearly that the present U.S. civil space program is too often viewed in the current era as a collections of disparate and discrete elements. In this thinking, the science program is then viewed as quite separate from other activities. However, the science program should be an integral part of the overall mission of the U.S. civil space program.

   As stated in my Testimony, the very different (from the last three or more decades) fiscal and international climate that the nation finds itself in requires a complete re-evaluation of the mission of the U.S. civil space program. At present, there is no over-arching vision or mission that is commonly agreed upon for the program.

   I believe that, consistent with the conclusions of the 1990 Augustine Committee examination of the civil space program, that space science should occupy the fulcrum of the program. The other programmatic elements - robotic and human piloted flight, as well as launch capabilities and technology - would follow naturally from this identified fulcrum.

   The space science program should be targeted towards major discoveries concerning the place of the Earth and its peoples within the solar system, the galaxy and the universe, and should endeavor, when possible, to deploy the knowledge obtained for practical and educational purposes. In terms of practical benefits, better understanding of the place of the Earth in the solar system will provide better knowledge of the effects of solar activity on communications satellites and on electrical power grids, as well as a better understanding of the natural causes of weather and climate changes that affect human food supplies and living conditions.

3. In recent years the Space Studies Board of the National Research Council (which I Chaired from 1988 through 1994) has published several reports related to the research priorities in planetary exploration, in solar and terrestrial physics, and in microgravity research (using both piloted and robotic flight). In addition, the community, principally through the Board, has been vigorous in its approach to prioritizing space science under the challenge of the smaller and cheaper missions. Finally, the Board has in the past conducted several examinations of how to accomplish prioritizations across wide discipline areas and has issued reports on its deliberations and on its example prioritization exercises.

AEROSPACE STATES ASSOCIATION

James Pagliasotti, Executive Director, 130 State Capitol, Denver, CO. 80203
Phone: 303/ 866-2087   Fax: 303/866-5469

May 30, 1996

U.S. House Committee on Science
Subcommittee on Space and Aeronautics

Testimony of the
Aerospace States Association
by
James Pagliasotti
Executive Director

Response to Additional Questions for the Record
dated May 21, 1996

Question:

Aerospace States Association (ASA) is requesting that NASA outsource programmatic responsibilities of its academic programs to the states If ASA were to get an agreement with NASA, ASA says that rural schools (ones away from NASA Centers) would get the same access to NASA space education resources as do schools that are near the NASA Centers.

- Have other agencies adopted a similar program to the one you are suggesting with NASA?

Response:

We believe that this would be a pathfinder project in outsourcing certain programmatic responsibilities from a federal agency, through a state-based non-profit organization, to the states. Certainly, we aren't aware of any program that exactly replicates our proposal

ASA is unique among non-profits. ASA represents the governors of its member states in aerospace policy issues. It is uniquely positioned to leverage federal space education monies Utilizing the influence of the executive branch of state government is a highly effective method to attract the interest of the departments of education, other state and local agencies, the private sector and the non-profit sector.

Subcommittee on Space and Aeronautics, page 2

The National Governors Association (NGA) represents all 50 of the nation's governors. Speaking as Chairman of the NGA, Wisconsin governor Tommy G. Thompson strongly endorsed the ASA proposal in a letter to NASA Administrator Daniel S. Goldin (copy attached).

The Education Commission of the States (ECS) is the education "think tank" for the nation's governors. ECS has endorsed the ASA proposal in a letter to Goldin (copy attached).

ASA is chaired by Colorado Lieutenant Governor Gail Schoettler. Its vice-chairs are Wisconsin Lt. Governor Scott McCallum and Washington Lt. Governor Joel Pritchard. Numerous other lieutenant governors serve as their state's delegate to ASA.

This leadership gives ASA a unique ability to identify and activate *in situ* resources within its member states and their communities. It is the key in our proposal to derive optimum value from federal space education seed monies.

Parallels with our proposal are difficult to draw because federal monies usually pass, via block grants or other such means, to state or local government agencies before being passed along to the non-profit sector for programs operated on behalf of the public good, which results in several layers of bureaucratic oversight and micro-management.

Conversely, grants that are given to individual non-profits for programs operated on behalf of the public good differ precisely because they have no formal ties to state government and therefore no specific mechanism to attract broad-based cooperation from the community.

Question:

- It is true states know what is best for their constituents, however, will states be able to provide a comprehensive space education?

Response:

The state departments of education currently see space education as a small niche within the larger math, science and technology arena. ASA sees space education as a critical integrator, or catalyst, for the study of those subjects. We are committed to making the case for space education at the state and local level.

NASA is the primary resource for space education and ASA is the delivery system. By "reverse contracting" with NASA Centers, and by identifying and contracting with other innovative space educators, ASA can ensure that the states have the tools to provide state-of-the-art space education as a core part of the education curriculum.

Subcommittee on Space and Aeronautics, page 3

We want to make it perfectly clear that NASA has tremendous space education resources. ASA is proposing a program that will greatly broaden NASA's impact via a "bottom-up" rather than the current "top-down" approach to outreach. We are convinced that a broad-based program to instill space education in the nation's K-12 classrooms and evaluate its impact on math and science literacy will result in a greater appreciation for and use of space education within the education community.

Question:

- How could NASA be guaranteed that the money allocated to ASA be used for space education only?

Response:

ASA has proposed a program of space education outreach to the nation's K-12 teachers and students. All monies will be used for that purpose.

The ASA proposal has two primary components that will be part and parcel of any and all programs funded under this proposal: providing space education training and tools to teachers for use in the classroom, and, evaluating the impact of space education in each of the 3 years of the pilot project.

ASA believes that each state can best determine its approach to implementing this space education project; however, ASA's role is to ensure that the primary components of the project are met.

Question:

The ASA proposal suggests a 3-year pilot project to conduct space education conferences and hands-on workshops for teachers, provide follow-on training at the local level to sustain and further space education interest, and provide a direct pipeline to the classroom for distribution of NASA education resources.

- In the Zero Base Review the emphasis was on outsourcing to reduce costs. How will ASA do a better job in educating K-12 than NASA?

Response:

Because of a declining budget, NASA must reduce costs. Unless programs are to be proportionately reduced, ways to leverage resources must be found. NASA needs help. ASA has proposed a means of broadening NASA's education outreach by leveraging federal dollars with state, non-profit and private sector contributions. We have accomplished such leveraging in four states and can do so on a much larger scale.

Cost savings will be realized not only through leveraging federal funding, but by reducing administrative costs. Much of what can be accomplished will be done by activating unutilized or under-utilized resources at the state and local level, spearheading volunteer contributions to the program, working creatively with existing space education and other educational organizations.

The philosophical underpinning of our proposal is the belief that the non-profit sector, in operating for the public good at the local level, can do things more efficiently and for less money than a federal agency. Salaries are lower, a high degree of volunteerism is utilized, procurement requirements are less burdensome, and so forth. Unless or until an institutional mentality develops, the non-profit tends to be driven more by passion than by job security. When that changes, we would suggest, it's time to find another, hungrier organization to carry the message.

Thank you for this opportunity to address your questions.

Responses by Dr. Joel Snow to Questions submitted for the record by Mr. Sensenbrenner

1) Do you support NASA's science institute plan?

1a) If so, why?

Yes. The concept of more fully utilizing the capabilities of the nation's universities is very positive. Unique research programs with world-class excellence exist in most states. Many of these have or could have relevance to NASA's mission. Thus the premise that the capability to manage and conduct significant portions of the NASA research effort outside of the Agency seems valid. Concerns arise when considering the implementation of the Institute concept.

1b) If not please explain.

The first concern relates to how the proposed eleven institutes were identified, ie. they were identified by only internal NASA teams. If the Agency is to maintain only those research functions which are unique or world-class, it seems that an external peer group should decide what NASA's unique scientific strengths are. In other words, if NASA were to compete for the funds to perform a given research function or program with other institutions recognized for excellence in the same field, would they win? If so, NASA should retain the capability. If not, it should be a candidate for performance in an external institute. The result of such an exercise may be a completely different set of science institutes. No external peer review has been performed.

The second concern relates to the location requirement of the proposed institutes. It is conceivable that world-class capability exists to perform the required research beyond the 50 mile radius from a given center. This other capability, in some cases, may exceed NASA capability and should form the nucleus of the research effort. The need to establish a presence near the sponsoring center is reasonable, but the requirement to establish core activities within 50 miles is an artificial requirement that could adversely affect cost and limit participation to other than the best available team.

1c) Give suggestions as to what could be improved.

Ask an external group such as the National Academy of Science or others to conduct a peer-review of where the world-class talent and facilities are (nationally or internationally) for the various NASA enterprises. The results will confirm if NASA has properly identified its own strengths. The same external team could then review the disciplines of the proposed institutes. Presumably, the Institutes should align with areas where the most scientific quality gains or cost savings could be achieved by forming an Institute.

The location requirement for the proposed institutes should be eliminated. It is reasonable only to require some presence for the Institute near the host NASA center. The center of activity for the institute should be where the greatest concentration of expertise and facility exists, which may not be within 50 miles of a NASA center.

2) How will the institutes affect Iowa State University?

Since there is no NASA center within 50 miles of Iowa State University (ISU), it is unlikely that ISU could lead any Institute effort, even if ISU has world-class capability in the field of interest. ISU would then be forced to compete for reduced research funds in an arena where as much as 25% of the funds available in the field go to the related Institute. The same impact would exist for any non-NASA state.

3) Is it fair for NASA to choose a university that is physically located near a NASA center for its science institutes over a university that is not?

No. Perhaps the question is, "Is it wise...". The issue should be the quality of the science, not the location. NASA science staff as well as Institute staff may have to travel to the location of the greatest capability for the related work. Forcing the Institute to within 50 miles assumes that this location of greatest capability is within the 50 mile radius of the host NASA center. This may not be the case.

4) Are those local universities better equipped to handle the institutes?

Possibly marginally. The NASA mode of operation has favored the local universities for many years. It is reasonable to expect that these local universities may have some programs that are almost tailored to some of NASA's needs. If an Institute is identified in the associated field, the local universities may be better suited to respond. Space biomedical research is an example. Houston is the place where the local academic institutions have developed a unique focus on a very specialized problem. However, the same may not be true for other disciplines. Advanced computing, computer visualization, materials research and testing, and other fields are examples where world-class talent and capabilities exist far from NASA centers.

5) Will those local universities gain a "leg up" over the other universities when it comes to attracting funding?

Yes. The NASA Cooperative Agreement Notice for the Space Biomedical Research Institute requires "Physical proximity for the core cooperative efforts..." to be within 50 miles of the Johnson Space Center. A similar pattern is expected for the other Institutes.

6) What type of information has NASA given to the universities regarding science institutes?

The development of the concept has been mainly internal to NASA. NASA has provided a letter from the NASA Chief Scientist to the Zero Base Review (ZBR) encouraging the establishment of Institutes. A benchmarking report from the NASA Science Institute Planning Integration Team was placed online for a time this winter. The NASA Science Institutes Plan of February 1996 is available to the public. The draft Cooperative Agreement Notice for the National Space Biomedical Research Institute is also publicly available. In addition, several key NASA people have been making presentations on the subject of NASA Institutes. There is no longer a central point within NASA concerning the Institutes. All of the Institutes will be implemented through the various internal NASA "enterprises".

Technology Transfer

7) How does Iowa State's success rate at transferring technology compare with NASA's success rate?

Two metrics which are commonly used by the technology transfer community are the number of invention disclosures received as compared to the level of research funding and the number of licenses compared to the level of research funding. Listed following are comparisons of these metrics for NASA, an average of 145 research universities and hospitals across the U.S. and the Center for Advanced Technology Development (CATD) at Iowa State University. While we recognize that our metrics may not be the only metrics used to measure success in technology transfer, we believe that they do represent important measures and are indicative of the strength of the CATD program.

INVENTION DISCLOSURES
per $10 Million Research Funding for FY94

NASA[1]	0.000001
U.S., Canadian Universities and Hospitals[2]	7.34
CATD, Iowa State University[3]	14.7

LICENSES
per $10 Million Research Funding for FY94

NASA[1]	0.000000015
U.S., Canadian Universities and Hospitals[2]	2.1
CATD, Iowa State University[3]	4.2

Source:

[1] NASA - Office of General Counsel (Estimated $7 billion research budget)

[2] Technology Access Report - Michael Odza and Association of University of Technology Managers Survey, 145 respondents

[3] CATD - Iowa State University

8) How do you account for the different number of license agreements between NASA and Iowa State?

Iowa State University's Center for Advanced Technology Development (CATD) has been demonstrated to be a very effective program for increasing the number of research results transferred to the private sector. The management of the unique process, as described in the answer to question 9, includes research and proactive industry feedback. The number of license agreements is an indication of that success. NASA appears to need to address and improve its focus on this aspect technology transfer efforts.

9) What is unique about Iowa State's approach to technology transfer and how does it differ from NASA's approach?

Iowa State established a new approach to technology transfer in its Center for Advanced Technology Development, formed in 1987. After 9 years of experience in tailoring later stage basic research to increase the likelihood that industry will adopt the technology along with proactive connections with industry, CATD has proven to be successful. Bridging the gap between basic research results and adoption by industry makes CATD unique and distinct from NASA's approach as well as others.

NASA's approach appears to place a greater emphasis on providing technical expertise to industry and developing databases of technologies which can be accessed by industry. Our experience has shown that this is not enough. Industry is not typically ready to accept the risk of taking on a new technology at an embryonic stage and the research will sit "on the shelf". The CATD approach, of bringing the technology further, before industry is involved, reduces the risk and increases the odds that it will be picked up by industry. CATD's numbers demonstrate the success of the approach.

Responses from Holland Ford

Q-1: How will the polar stratospheric telescope (POST) enable the astronomy community to weather this dry spell in space science funding?

A-1: Capabilities normally attributed to space telescopes (Hubble-like resolution, an extremely dark sky, and absence of atmospheric absorption) can be achieved by POST for approximately 10% of the capital and operations cost. POST will fill the gap both scientifically and technically between HST and the Next Generation Space Telescope.

Q-2: Do we have time to study the program in more detail for a start in Fiscal Year 1998 instead of Fiscal Year 1997?

A-2: Yes, POST could be started in FY 1998 instead of FY 1997. However, starting in 1998 would delay producing answers needed by an potential study group. Furthermore, the Dutch are pushing their part of the studies. Consequently, a delay would weaken U.S. leadership in the project.

Q-3: You mentioned that we could start work on POST in Fiscal Year 1997 for just $2 million dollars and that it would cost $100 million dollars to fully develop and operate POST for several years. How do POST's costs compare with other major observatories?

A-3: POST would be far cheaper to build and operate than any space telescope. Operating and capital costs would be similar to ground based facilities like GEMINI and the KECK observatory. Its performance would exceed that of these facilities in several crucial aspects mentioned in question 1. Finally, POST would cost far less to operate than an airborne telescope.

Q-4: Post seems to share many of many of the advantages of the Stratospheric Observatory for Infrared Astronomy (SOFIA), both in terms of the science it can do and in terms of cost-sharing among international partners. What roles do you think the Australians, Dutch and Italians would play in POST?

A-4: The Dutch have established a scientific and industrial (Fokker Aerospace) team to participate in planning and engineering studies. Their stated goal is to contribute approximately 30% of the total cost of POST. The Italians would participate by providing a ready-to-fly payload with a value of more than a million dollars. The Australians plan to operate POST at the very best site on the planet, the stratosphere above the high, dry, and extremely cold Antarctic plateau.

Q-5: What role might POST play in pursuing the Origins program that NASA would like to initiate?

A-5: POST would directly address two major themes in NASA's Origin's program. First, POST would provide an unparalleled look at the origin of galaxies in the early universe. Second, POST would allow astronomers to study the formation of planets and solar systems with Hubble-like resolution at the near-infrared wavelengths where they emit most of their light.

MAJOR GENERAL LANCE W. LORD'S RESPONSE TO QUESTIONS SUBMITTED FOR THE RECORD BY CHAIRMAN SENSENBRENNER

The Air Force is in the process of developing a Clementine 2 mission to demonstrate advanced miniaturized spacecraft technology and test some new microsatellites at a very low cost. In the course of this mission, Clementine 2 presents a unique opportunity for science to study the makeup of several asteroids, which is partly why it enjoyed bipartisan support in both the 103rd and 104th Congresses.

- Would Clementine 2's science benefits be improved if NASA provided its expertise and capabilities in spacecraft tracking, data relay, sensor calibration, and scientific exploration to the Air Force?

Based upon the constructive experience of Clementine I, the Air Force would benefit by NASA's deep space exploration capabilities. Based upon lessons learned on Clementine I, we recommend more NASA up-front participation in the area of critical sensor calibration. It is our hope on Clementine II that NASA can support the Air Force in a more direct and collaborative manner as a closely linked joint endeavor.

- Could you update us on the status of this program and offer any insight about when the funds authorized and appropriated in FY96 will be released?

Air Force Space Command is working actively with the Air Staff and the Office of the Secretary of Defense to ensure the release of FY96 funds. There has been some questions concerning the prime mission by the Deputy Undersecretary of Defense (Space) which are being addressed. The main issue is that planetary defense is not a DoD mission. However, the Air Force has structured the FY96 micro-satellite program that follows our interpretation of Congressional intent, does not violate any treaty obligations, maximizes investment benefits, and leaves the options open on space mission requirements. Based on these facts, we anticipate the funds to be released in a matter of weeks.

The Air Force and other uniformed services are discussing ways of leveraging private sector investments in space to create new operational capabilities for the military in areas ranging from communication to intelligence collection.

- Please explain how the Air Force views emerging commercial communication and remote sensing capabilities?

Air Force Space Command views emerging commercial communication and remote sensing as capabilities to be exploited. Commercial communications capabilities should serve civilian and military users alike, by providing quick and timely access, fielding new technologies and augmenting military systems during crisis situations.

Similarly, the emerging commercial capability in remote sensing satellites can augment military remote sensing by providing additional coverage and providing sensors with unique capabilities complementary to military sensors.

Critical to this process is getting involved with commercial efforts early in their planning stages--assuring compatibility and interoperability with military systems and minimizing costs required to tailor system functionality in support of our military missions.

In our mission area planning process, through integrated product development teams and in conjunction with the DoD Space Architect's office, we are trying to determine what will be the best mix of dedicated military space systems and commercial space services. We must assure that our total capability provides reliable, responsive and secure communications and remote sensing coverage.

I understand that the Air Force is actually basing some of its mission planning on the availability of commercial space services. The Eagle Vision program, for example, will provide warfighters with a transportable ground station to receive and process commercial remote sensing images.

- Why is the Air Force using these private sector capabilities instead of procuring its own satellites?

Air Force Space Command is interested in using private sector space-based capabilities as a cost effective way to enhance our mission effectiveness. The cost to the government to develop and field satellites which match the capabilities and coverage of planned commercial communications and remote sensing systems would cost billions of dollars.

We believe we can exploit commercially available services for a small fraction of the cost of procuring and operating military satellites of similar capability. Clearly, we must do this prudently in order to be sure we preserve the ability to meet military requirements of timeliness, guaranteed access and security. The money saved by purchasing commercial services could be used to develop and field satellites needed to satisfy unique military requirements not satisfied by the commercial sector.

In our mission planning, we are examining the appropriate mix of commercially provided space-based capability to complement our military systems to assure reliable, responsive and secure operations.

Past cooperation between NASA and the DoD on programs such as the National Launch System did not work very well. Personnel exchanges seem like a more constructive way of leveraging the talent in both agencies. However, conventional wisdom usually tells us that the careers of personnel who accept billets outside of their respective services sometimes suffer as a result.

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- How is the Air Force working to ensure that this does not happen?

The Air Force is working hard to ensure participation in personnel exchange programs will continue to offer career enhancing responsibilities that can translate into effective performance appraisals and promotion recommendations.

In late 1995, DoD/NASA Personnel Exchange Integrated Product Team (IPT) envisioned a two year tour in the NASA organization for three exchange officers, followed by return to the sponsoring DoD organization for one to three years to put the officer back into their mainstream career path. Currently, the Air Staff is discussing changing the tour length to one year to strike a balance between Officer Professional Development impacts while meeting the intent of the exchange program and ensuring solid, meaningful responsibility is assigned while on exchange. While it is not uncommon for an officer to career broaden, the length of time the individual spends outside the primary career field is critical. In addition, we attempt to keep the officer attached to the sponsoring DoD organization which alleviates many concerns such as performance reporting, cost of PCS/travel, funding requirements for transfer, and management of billets.

Congress added funds to the Air Force budget for several advanced technology programs in FY96, including a complementary program in advanced launch technology intended to look for ways to leverage NASA's X-33 program in order to meet national security requirements. The Defense Department, however, has not released these funds to the actual program offices that will do the work.

- How soon can we expect these funds to be available to their respective program office?

The Air Force has requested the Office of the Secretary of Defense (OSD) release funds for the program on advanced launch technology complementary to NASA's X-33 program. OSD has not yet released the funds pending the receipt of a program plan from the Air Force. A date for when these funds will be released by OSD has not been established.